POWER PLANT ENGINEERING

Established Over 29 Years

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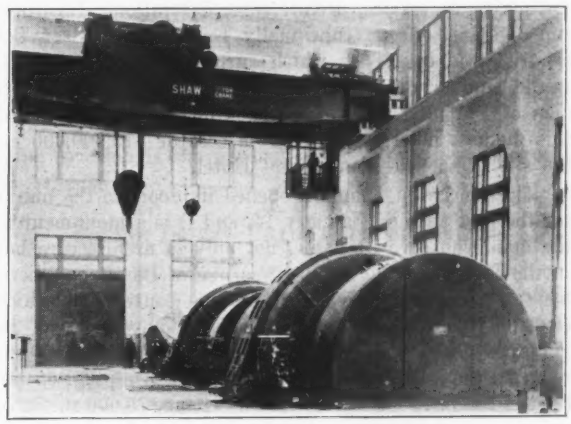


Roamin' in the Gloamin'

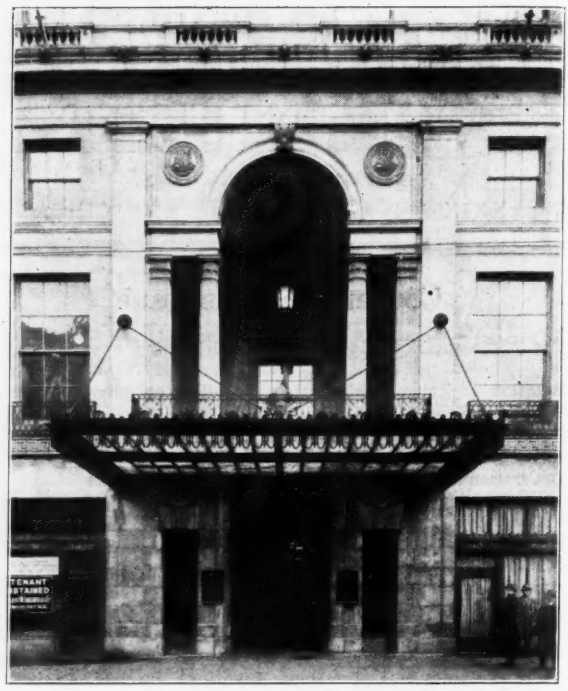
AS HARRY LAUDER, the great Scotch comedian, used to sing about it, "roamin' in the gloamin', wi' your lassie by your side" may be a wonderful outdoor sport, but in a power plant there shouldn't be any gloaming at all for anybody to roam in. In the turbine room pictured above, for example, there is no gloaming morning, noon or night. We have seen plants, however, in which it was necessary to strain your eyes every minute to avoid stumbling into a moving machine or where it was necessary to use extension lights to work on the outside of almost any machine in the plant.

Cheerful, well-lighted power plants such as that shown above are becoming more and more numerous, we are glad to observe. On page 487 of this issue, A. F. Loewe tells how such pleasing conditions can be obtained by proper painting of walls and ceiling and by intelligent use of lighting fixtures, together with scientific methods of locating them, as advocated by modern illuminating engineers. After reading his article, we think you will agree that there is no excuse in the modern power plant for "roamin' in the gloamin'" with its attendant lessening of human efficiency.

FOREIGN MATTER in Diesel engine fuel oil, either in the form of fine dirt or water, may cause considerable trouble in the engine cylinders. To remove this suspended matter, centrifugal treatment may be resorted to. Tests of a centrifuge, treating oil supplied to an engine under actual operating conditions, are described on page 484 of this issue and the results are interesting to all operators of Diesel engines.

The Benjamin Franklin Operates Oil-Burning Power Plant

PHILADELPHIA'S NEWEST HOTEL COMBINES COLONIAL BEAUTY OF INTERIOR DECORATIONS WITH MODERN MECHANICAL AND ELECTRICAL CONVENIENCES FOR THE COMFORT OF ITS GUESTS



WHEN THE GUEST steps into the door of The Benjamin Franklin, he is met by an attendant in a uniform similar to that worn by the leaders of our country on state occasions one hundred and fifty years ago. The entire hotel is distinctive in service, architecture, decorations, furniture and lighting effects, continually reminding you of the beauties and courtesies which surrounded the well-to-do at the time our country became independent. The business men of Philadelphia who are back of the project erected this modern hotel structure at a cost of $13,000,000 on the site of the old Continental Hotel.

The Benjamin Franklin opened its doors to the public for the first time on January 14, and it is a monument to the man who bore its name, not only in architecture but in the fact that, as Franklin was one of the early experimenters with electricity, every modern convenience which electricity affords for the comfort and convenience of its guests is found here. To serve its 1200 guest rooms has required the installation of 70 mi. of steam piping, 65 mi. of steel conduit, 300 mi. of electric wiring, 75,000 sq. ft. of radiator surface, 20,000 electric outlets; each guest room has a bath and shower (28 on each floor from fourth to sixteenth) and the floor space covered totals 18 acres.

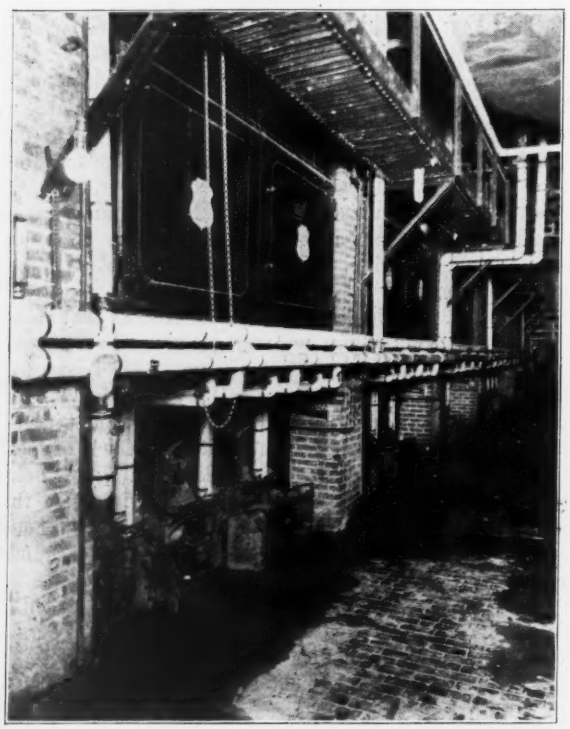


FIG. 1. OIL BURNERS KEEP COAL DUST AND ASHES OUT OF THE SUBBASEMENT

It would be difficult to find a power plant that has a more diversified field of service than that in a modern large hotel. Here is developed all the heat and power used throughout the building; all the water used in the hotel is forced to its point of service by pumps in the engine room; clean, fresh air reaches all parts of the building through fans driven by power from the generators; cool, purified water and ice for all purposes are products of the power plant; steam for the laundry and kitchens, hot water for baths, brilliant lights for ball rooms and banquet halls as well as the restful, subdued light for the bed rooms, power for elevators, suction for the cleanly vacuum sweepers all depend upon the services which the power plant renders. Way down in the heart of the basement out of sight and hearing, the power plant imparts the life and maintains the health of the up-to-date hotel.

STEAM GENERATED WITH FUEL OIL

In the Benjamin Franklin Hotel, the power plant equipment is located in the southeast corner of the second basement, the lowest floor in the building. Steam is generated in six type "H" Heine boilers, each having a heating surface of 3053 sq. ft. and a rating of 300 hp. Oil is used for fuel here, not only because it is more desirable than coal on account of its cleanliness but it is more economical due largely to the cost of delivering the coal and removing the ashes. One boiler, however, is fitted with a grate for burning coal in case of an emergency. Each of the five other boilers is served by three oil burners furnished by the W. N. Best Corp.

Oil is stored in two tanks of 22,000 gal. capacity each, located across the firing aisle from the boilers. From the tanks the oil is pumped through a heater to the burners, being fed at a temperature of 185 deg. and a pressure of 8 lb. Steam for atomizing the oil as it leaves the burners is taken from the header at boiler pressure, 150 lb. Four

boilers are kept in service, three being worked at a steady load with the fourth taking the swing. A Spencer damper regulator is installed but is used only when coal is burned.

Bayer tube blowers are provided on the boilers designed for 165 lb. steam pressure and are used regularly once a day. The safety valves were made by the Ashton Valve Co. and the blowoff valves by the Nelson Mfg. Co., both surface and bottom connections being provided. Blow down water discharged from the boilers goes to a blowoff tank in which is placed a coil through which the house water passes on its way to the heaters; thus the heat of the waste water is absorbed. The blowoff tank is vented to the roof through a 6-in. pipe by the side of the stack. One stack, which is of steel, 10 ft. in diameter, serves all the boilers and is carried above the roof of the hotel in a shaft which also accommodates the atmospheric relief pipe. Furnace draft is indicated by Huyette draft gages, one of which is provided for each furnace.

Water used for feeding the boilers is principally the returns from the heating systems which are brought back to the open feed-water heater located in the engine room. Make-up water is fed into the heater automatically from the supply tank on the roof. Two feed water pumps are located in the boiler room and deliver the water from the heater direct to the boilers. These are Burnham, simplex outside end packed plunger pumps, 14 by 16 in., made by the Union Steam Pump Co., pot valve type and are controlled by Schade pump governors. Water may be fed to the boilers through either of two feed lines, one at the front and the other at the back of the boilers. In case the feed pumps fail to operate for any reason, four Schutte and Koerting injectors may be used, taking cold water direct from the supply system.

Steam is generated at 150 lb. pressure without superheat and carried at this pressure through overhead piping to the main units and steam driven pumps. The main header is 14 in. in diameter and in the form of a loop back of the boilers and through the engine room, permitting the isolation of any boiler while the others are in operation. The kitchens, laundry and tailor shop require steam at lower pressure which is supplied through Schade reducing valves located in the boiler room. The principal steam valves were made by the Nelson Mfg. Co. and the magnesia pipe covering is the product of the Norristown Magnesia & Asbestos Co.

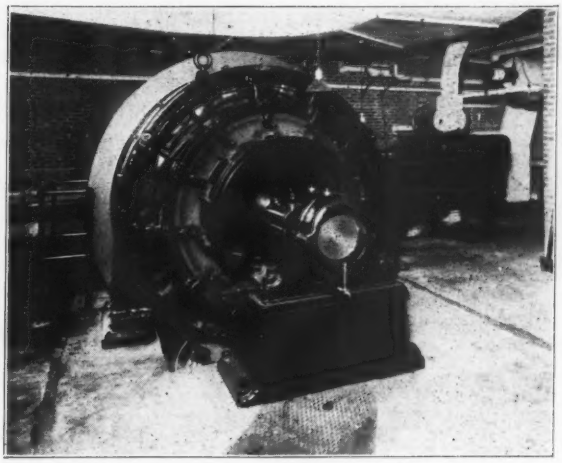


FIG. 3. FROM THIS POINT IN THE ENGINE ROOM, THE OPERATOR GETS THIS VIEW OF NO. 3 UNIT, A SIMILAR VIEW OF NO. 2, A COMPLETE VIEW OF THE SWITCHBOARD AND A GENERAL VIEW OF THE PUMPS

Engine Driven Units Furnish Current

Three direct current generating units are located in a row down the center of the engine room, taking steam through 10 in. branches from the main header, each branch being provided with a direct separator. These consist of Erie Ball engines, each of 600 hp. rating, the cylinder dimensions being 22 by 33 in., direct connected to Burke generators of 400 kw. capacity. The speed at which these units run is 150 r.p.m., the voltage generated is 220 which, with the three-wire system of distribution, gives 110 v. for lighting and 220 v. for power. The Hills-McCanna system of lubrication is used on these engines.

Being located so far below the surface of the ground, some form of artificial ventilation must be provided for the workmen in the power plant as well as air for combustion in the boiler furnaces. This is accomplished by a balanced

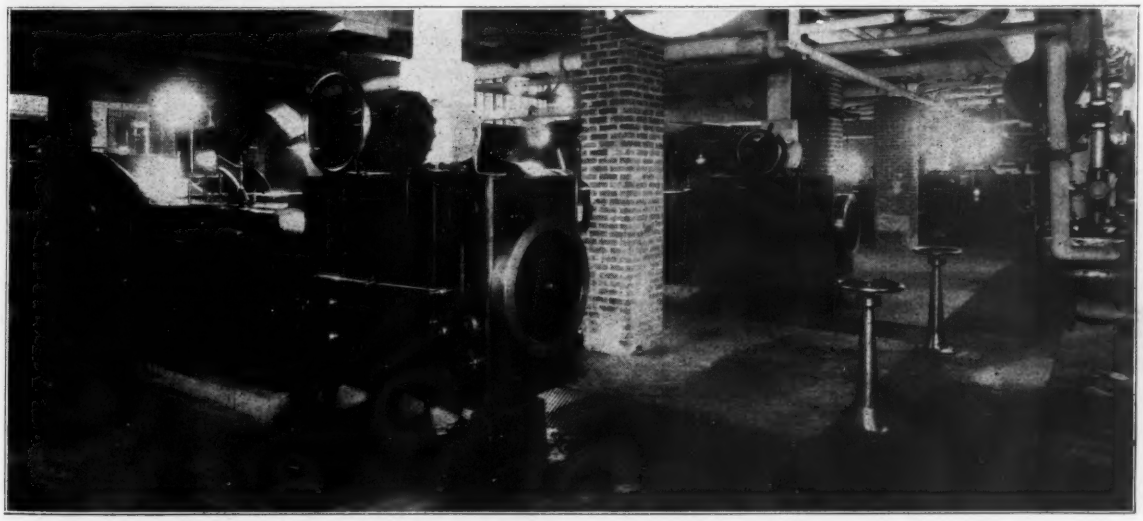


FIG. 2. THREE GENERATING UNITS ARE CONVENIENTLY SPACED IN THE CENTER OF THE ENGINE ROOM

system of ventilation which maintains atmospheric pressure in the rooms by drawing air through a duct having its intake at the second floor level, and delivering it to various parts of the subbasement. This system, which was installed by the Baker Smith Co., makes use of a Sturtevant fan, located in the engine room, driven by a 9-hp. Westinghouse motor running at 207 r.p.m.

All the sewage from the basement and subbasement drains to a sump beneath the engine room floor from which it is delivered to the city sewer system by three air ejectors rated at 190 g.p.m. each. Compressed air for this purpose is furnished at 45 lb. pressure by two Ingersoll-Rand air compressors, each 10 by 8 in., driven through a short belt and are coupled direct to 40-hp. Burke motors. The discharge from these pumps goes into the water piping system of the building, the surge being taken by two tanks on the hotel roof each of 22,000 gal. capacity. Floats in the surge tanks automatically start and stop the pumps as the level in the tanks reaches the lower and upper limits, through Cutler-Hammer control mechanism. Walworth valves are used throughout the water piping system.

Heating of the building is done by exhaust steam from the main units and steam-driven auxiliaries, the Warren Webster system being used. The back pressure carried is 1½ lb. and the vacuum on the return piping is maintained at 5 in. of mercury by two Burnham vacuum pumps each

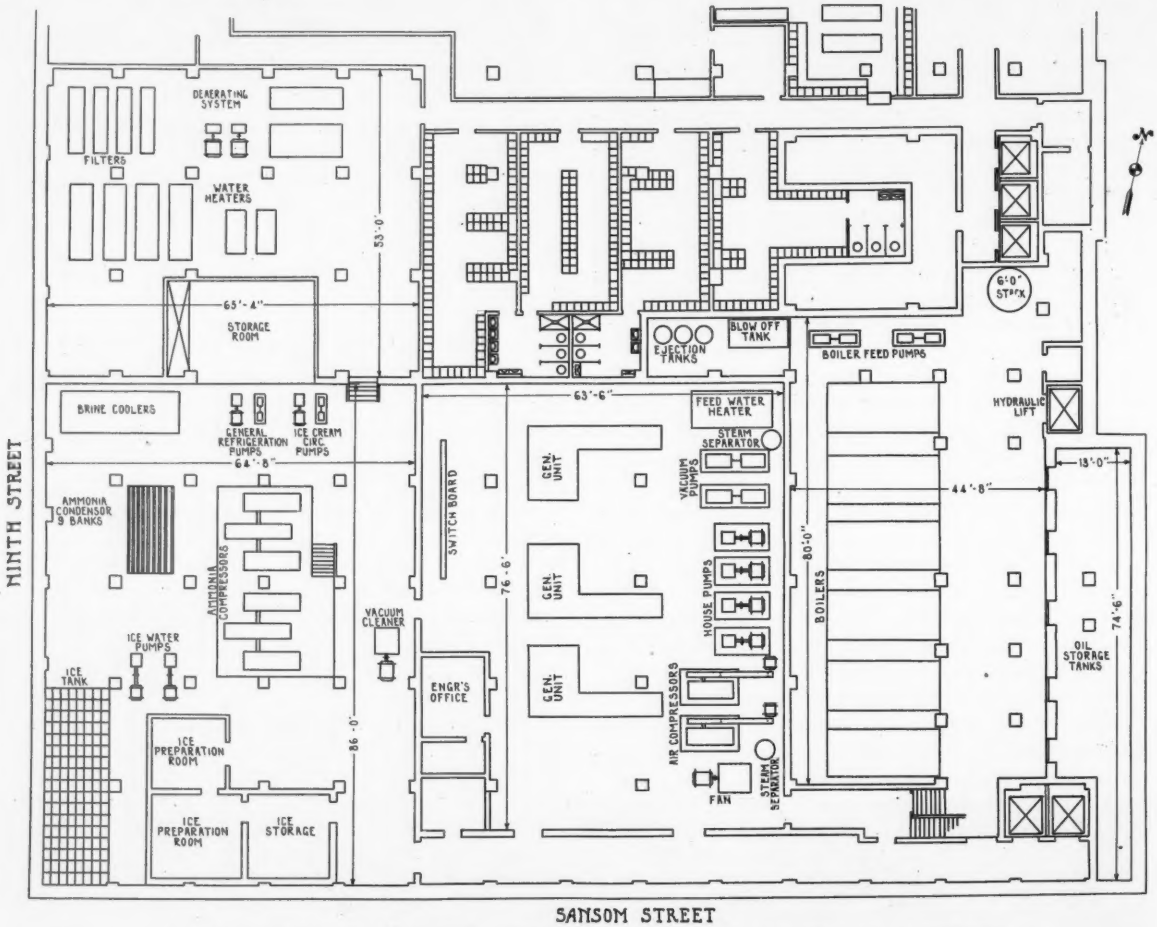


FIG. 4. GENERAL PLAN OF THE POWER PLANT FLOOR AND LOCATION OF EQUIPMENT

connection by Imperial Electric Co. motors of 25 hp. rating and speed of 1150 r.p.m. The motors are automatically started and stopped to maintain the pressure in the receiver within working limits by means of a device manufactured by the Monitor Control Co. of Baltimore, Md., Square D line switches being employed.

Centrifugal Pumps Handle House Water

House water must be pumped from the filters fed by the city mains, raising its pressure so that it is available in all parts of the hotel. For this purpose, four three-stage centrifugal pumps are used. These are rated at 250 g.p.m., each under a head of 270 ft. running at a speed of 1800 r.p.m. They are the product of the Union Steam Pump Co.

14 by 20 by 24 in. These are simplex steam-driven units, taking steam at 150 lb. pressure and are controlled by Schade pump governors. The condensate is discharged into a vented receiver tank from which it flows by gravity to the Cochrane feed-water heater under the control of the regulating valve. The temperature of the water as it leaves the heater is between 212 and 218 deg. F.

All steam-driven equipment exhausts into a common header which feeds the heating system and the heating equipment using steam at 1½ lb. pressure. Oil is removed from the exhaust steam by a separator on the heater, the oily condensate running to the sump with the sewage. The pressure is maintained on the heating system by a back pressure valve located on the roof of the building.

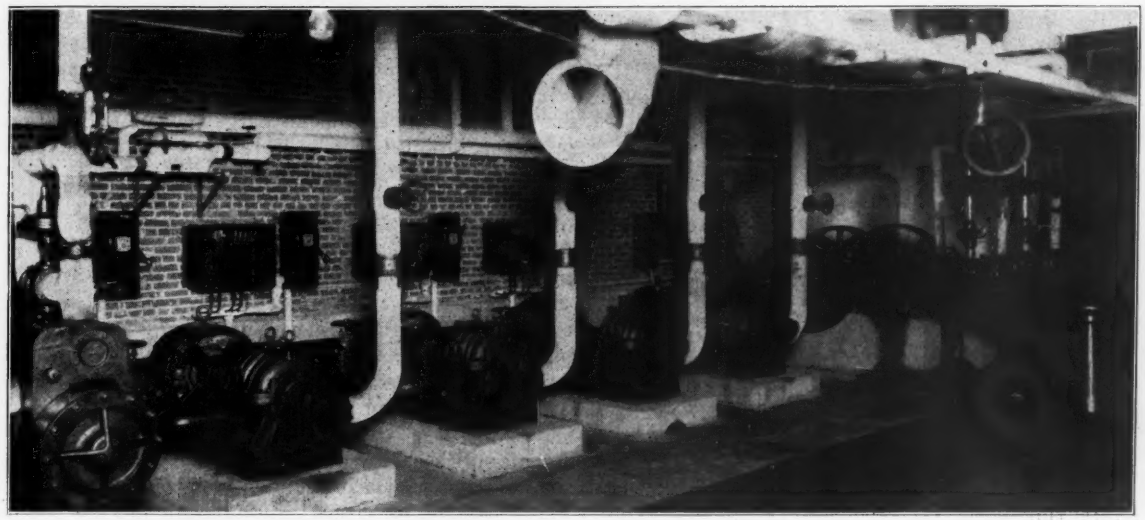


FIG. 5. HOUSE PUMPS, AIR COMPRESSORS AND VENTILATING FAN ARE DRIVEN BY AUTOMATICALLY CONTROLLED MOTORS. TWO INLET AND ONE EXHAUST VENTILATING DUCT OPENINGS SHOW PROMINENTLY

In Fig. 7 is shown the main switchboard along the west side of the engine room, consisting of three generator, one totalizing and three service panels. This switchboard was installed by the United Electric Co. and is equipped with Sangamo indicating and integrating wattmeters, General Electric Co. indicating ammeters and voltmeters, Esterline-Angus indicating and recording ammeters and voltmeter, I. T. E. circuit breakers and Pringle knife switches. Voltage is kept constant by a General Electric Co. voltage regulator for d.c. generators that employs a counter e.m.f. motor.

The engine room gage board is located on the wall back of the house pumps and the instruments mounted upon it indicate the boiler pressure in the laundry and that in the kitchens. These are all Ashton pressure gages.

In case of fire, alarm is given by a system designed by the Holtzer-Cabot Electric Co., which not only gives sound signals of the location of the fire, but also makes a record on a tape in the engineer's office. Current for operating this system is taken from the 110-v. switchboard bus.

When the pre-signal is given, it registers the number and location of the box pulled and, at the same time, it rings on the elevators, the location and the number pulled. They are dropped to the lowest level to receive a responsible person to investigate, who, after examination, determines whether a general alarm should be given. At intervals, the employes have regular fire drills. An alarm is struck to train those who are a part of the fire brigade. Immediately after the signal is given, the fire department is on the spot at work with hose and other fire fighting equipment. While this is all taken care of with despatch, the possibility of fire getting beyond the rooms is remote, as metal door frames, fireproof partitions, reinforced concrete floors, and other incombustible material is used in the construction of the building.

Throughout the entire hotel, the principal clocks are

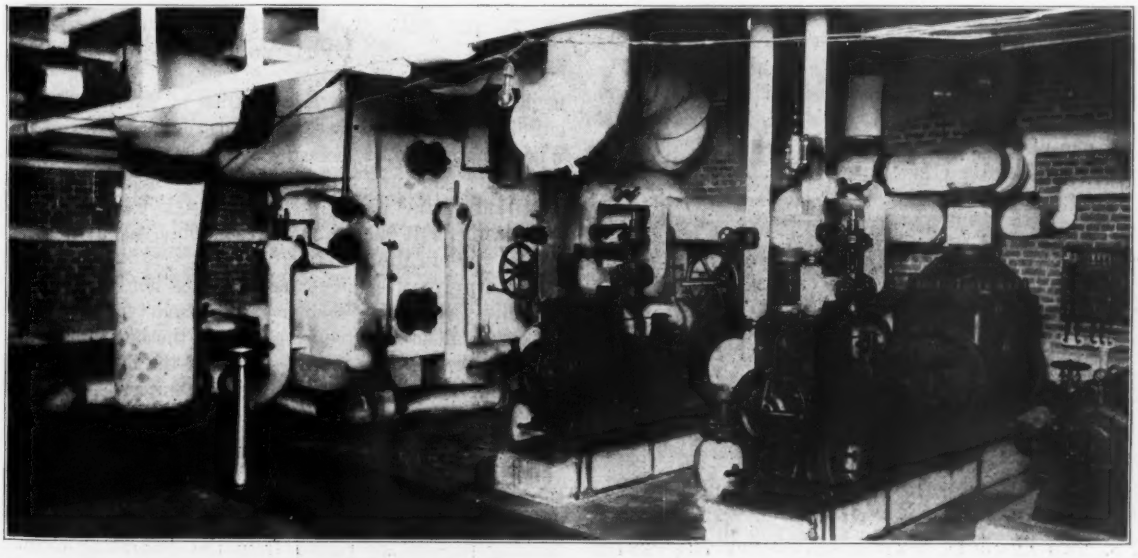


FIG. 6. FEED-WATER HEATER AND VACUUM PUMPS

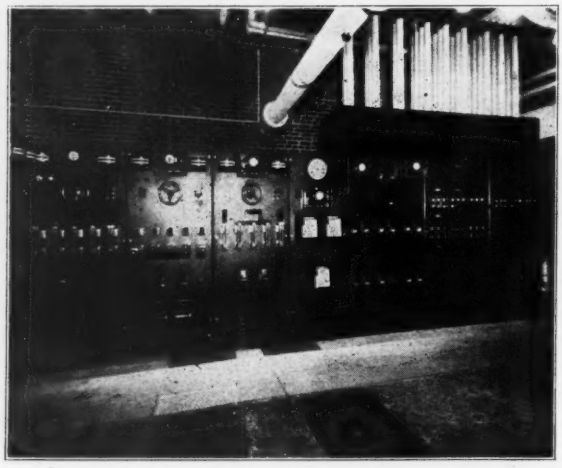


FIG. 7. THE SWITCHBOARD IS DESIGNED FOR THREE-WIRE DISTRIBUTION WITH ALL CIRCUITS CLEARLY LABELED

run by electricity from a storage battery which, together with the control mechanism, is located in the engine room.

Ice and Refrigeration Service

In the room to the west of the engine room is the ice and refrigerating machinery which makes all the ice used in the hotel, cools the circulating drinking water and furnishes refrigeration for the various ice boxes and cream freezers. The main units are two 65-T. Triumph ammonia compressors, 13 by 24 in., driven by direct-connected Hamilton Corliss engines, 16 by 36 in., the pressures carried on the compressors averaging between 90 and 150 lb. on the head and 12 to 15 lb. on the suction side.

Water used for cooling purposes in the double pipe ammonia condenser, which consists of nine banks, comes direct from the city mains and after passing through the condensers goes to the house pumps which deliver it to the surge tanks on the roof.

Drinking water is obtained by condensing live steam from the boilers with water drawn from the city mains. This distilled water is cooled by direct expansion coils and circulated through the drinking water system at 38 deg. by two centrifugal pumps, manufactured by the Chicago Pump Co., driven by 10-hp. Triumph motors. The pressure carried is about 115 lb.

For use in the cream freezers, brine is cooled down to —2 deg. F. and circulated by two Worthington centrifugal pumps, one of which is driven by a 10-hp. Worthington steam turbine and the other by a 7½-kw. Triumph motor.

FIG. 8. TWO AMMONIA COMPRESSORS OCCUPY THE CENTER OF THE REFRIGERATING ROOM

The discharge pressure is carried at about 46 lb. For general refrigeration, the brine is circulated at a temperature of 12 deg. F. by two Worthington centrifugal pumps, one being turbine and the other motor driven, the rating of the drive being 25 hp. and the discharge pressure 65 lb. Cork insulation, installed by John R. Livzey & Co., is used on all refrigerating piping and equipment.

Ice is made from distilled water taken from the drinking water system. The ice tank has a capacity of 160 cans, freezing 300-lb. cakes of ice. The brine used is the returns from the general refrigerating system. The ice when harvested goes to the preparing room, which is equipped with a crusher, cuber and shaver. The hotel employs an ice sculptor to carve out designs in ice used for decorative purposes in dining rooms and banquet halls. This work is done in the ice preparing room.

On the gage board in the compressor room are seven American Schaeffer & Budenberg pressure gages indicating the head and suction pressure on each compressor, the ice water pressure, ice cream brine pressure and the general refrigerating brine pressure.

Preparing the Hot Bath

Preparation of the service water, that is, water for baths, toilets, laundry, dishwashing, etc., is by no means

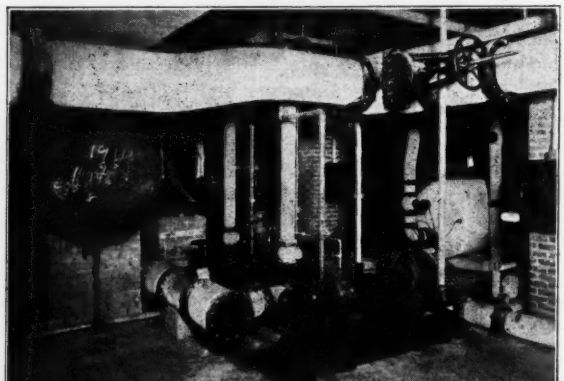


FIG. 9. THE DEAERATOR IS THE LIFE SAVER OF THE HOT WATER PIPING SYSTEM

neglected in this hotel. Every gallon of water used in the building is filtered as it comes from the city mains. Four Wheelwright, size 72, pressure filters are provided for this purpose. They are back washed once each day and the condition of the water during the back washing process and also after it has been filtered is observed by means of a sight glass in the pipe line.

As a preventive for corrosion of the hot water piping, an Elliott deaerating system of the flash type is installed to remove all of the free oxygen from the hot water before it passes through the piping system of the hotel.

In the heating element of this deaerator, the temperature of the water is maintained at 200 deg. F. by exhaust steam under the control of a Powers regulator. The water is passed from this heater, which is of the instantaneous tube type, to the air separating chamber, where it is flashed down to a temperature of 180 deg. The vapors from this flashing process are passed from the deaerating chamber into a surface condenser, which is cooled by the supply

water on its way to the heater for heating. The heat liberated in the flashing process is recovered in this condenser and the non-condensable gases removed by an air ejector and delivered to an aftercondenser for the purpose of condensing operating steam of the ejector. The water is removed from the deaerator chamber by two Worthington centrifugal pumps each of 250 g.p.m. capacity, driven by General Electric motors, which deliver the water to the hot-water system and maintain the service pressure.

In the delivery line from the deaerator, the water is passed to six Whitlock closed heaters, the temperature of which is maintained between 170 and 175 deg. These Whitlock closed heaters are of the storage type. The condensate from all heaters returns with the condensate from the heating system to the vacuum pumps, which maintain a vacuum of 5 in. on the trap outlets and simultaneously return all condensate to the system.

Elevator service in the hotel consists of 13 Otis overhead traction electric passenger elevators serving all floors of the building, two 2-story electric elevators serving principally the kitchen and one steam-hydraulic lift used for removing ashes from the boiler room.

In the ventilating system 20 motor-driven fans are used; these give a load of 500 amp. at 220 v. on the generators. Fresh air is supplied from the second floor elevation through an air filter and supplied to all parts of the hotel where needed. In the basement and subbasement Vento heaters are employed. The exhaust fans keep all parts of the hotel well ventilated, ducts being connected to all the inner rooms, corridors, halls and bathrooms.

Throughout the entire building vacuum piping is provided to which sweepers may be attached. A vacuum of 3 in. is maintained in this piping by machinery manufactured by the Spencer Turbine Co. and located in the power plant. A 20-hp. motor is required to drive this cleaner.

In the engineer's office are instruments which keep the man in charge informed as to the principal conditions being maintained in the plant. These consist of a high pressure steam gage, high pressure recording steam gage, recording steam gage on kitchen piping, recording steam gage on laundry piping, recording steam gage on the heating system and a telotype machine to receive messages from the hotel office. These gages are all Ashton instruments.

Horace Trumbaugh, of Philadelphia, is the architect who had charge of the design of this hotel, Horace Leland Wiggins is managing director and J. Roy Carroll is the chief engineer in charge of the operation of the mechanical and electrical equipment of the hotel.

Relation of Boiler Equipment to Coal Buying

CHARACTER OF COAL AVAILABLE AND DEMAND TO BE PLACED ON BOILERS MUST BE KNOWN BEFORE SELECTING EQUIPMENT. BY DOUGLAS HENDERSON*

BUILDING A NEW boiler plant is not something that can be done in one's spare moments if one is at all desirous of having a satisfactory job in the end. Too frequently, however, this is the case and almost immediately after the new plant is in operation a host of unforeseen difficulties arise which make the owner feel as if he had jumped out of the frying pan into the fire.

Sometimes the new plant proves to be such a vast improvement over the one that it replaced that a glow of satisfaction follows, but that feeling of relief is short-lived because conditions develop before long that were never even thought of and they are of sufficient intensity to keep that department of the business in a turmoil.

The average industrial plant with its four, five or six boilers is just the type that encounters the disagreeable climax, simply because insufficient care was exercised in the consideration of all the facts in the case. It is common to find, nowadays, the design of a new boiler plant proceeding along the lines of selecting equipment from descriptive literature and, the price being satisfactory, the actual purchase of the equipment follows. Later on when the new plant is operating it becomes necessary to buy coal for it and a cut and try method is resorted to.

High volatiles, low volatiles, high ash and low ash fuels are purchased and sent to the boiler room for burning. The price is the main consideration while the quality is taken for granted. The inevitable result of this procedure is to find that one coal causes clinkers, another gives trouble from smoke and still another doesn't seem to burn. Never is there any conclusive data on the results of any trial shipment but rather a collection of personal observations as to effects. That makes it extremely difficult to run down the causes and the cut and try method is persisted in.

This is equally true of plants that add a boiler or two to an existing boiler room. Little attention is paid to the different circumstances in the case but the whole idea is to alleviate some particular trouble by the new installation. There is, for example, the plant that decided to increase the boiler capacity by one new unit because it was having trouble to carry the load on the present boilers. It looked as if the difficulty was due to the lack of boiler capacity, hence a new one was obtained. It was connected to the old stack and when placed in operation, much to the disgust of the owners, the plant was practically as badly off as ever. The difficulty had been inadequate draft and the new boiler really made matters worse rather than better.

One curious story can be told of a small plant located in the east which boasts of a two-boiler installation. This plant had originally been fired by hand and its boiler room contained horizontal return tubular boilers. Some 3 yr. ago it was decided that the plant should be modernized and towards that end two new water-tube boilers were purchased. The size selected was such that one boiler would be capable of handling the entire plant load and no particular attention was paid to the type of unit other than from the initial cost standpoint and the time of delivery.

Next in order came the discussion of coal burning apparatus but without a thought of the type of coal that ought to be burned. This plant was in the region served by soft coal and naturally this was the only distinction that was made. After arguing for some time the management took a strong stand and decided to equip these two boilers with underfeed stokers. That was done to improve the physical condition of the boiler room and to make it relatively easy to keep firemen. In getting the stokers for this installation the paste pot and scissors were made use of.

*Chief Engineer, Fuel Engineering Co.

Lists of this kind of equipment were canvassed and several picked out, from which proposals were solicited. After receiving them, they were scrutinized closely with reference to the price. Finally one was found that for one reason or another outshone the rest and that one was decided upon. Three retorts were installed because the width of the boilers that were already purchased would not permit the installation of any more. The work of erecting the new units was soon completed and the management settled down to other things with the feeling of assurance that at last one of our plants has been brought up-to-date.

Load Demand Increased

There were just two considerations that had been neglected in that job, one was the quality of coal to be burned and the other was the possibility of increasing steam demands. They seem like small details but their effects were crushing in importance. That plant happened to be located on a railroad connection that limited the purchase of coal to mediocre fuels. Furthermore, the coal was all from a high volatile region, which fact ought to have been considered in order properly to construct the furnace volume. The plant increased its business in a normal rate and the one boiler on the line was forced to higher ratings than had been intended. It was always possible to put on the line the idle boiler but that would not have been advisable nor according to modern practice which demands an idle unit for emergency and repair.

These "fitted" stokers brought about an unfortunate condition in which there was insufficient grate area and the coal had to be burned under high rates of combustion. This in turn increased the furnace temperatures and tended to introduce clinker difficulties. To avoid such trouble it became necessary to buy coals having higher ash fusing temperatures and the available fuels on this particular railroad did not offer any such choice. After the installation was completed there was no practical way in which more grate area could be installed without considerable expense and the newness of the plant made the thought of any further expense preposterous. The management preferred to go along hoping to find the proper kind of coal and it will continue its quest for some years until it becomes convinced that perhaps the equipment is at fault. Then will come an urge for some change but not until considerable time and money has been spent in trying to dodge the inevitable. A boiler plant oversight will always come to the surface, it is like murder. To make matters worse, the boilers were so placed with respect to the plant that no more can be added unless an entirely new site is selected for a new boiler plant. Under such conditions the present arrangement will have to go along and with it go medium efficiencies of operation.

Proper Coal Should Be Had

That matter of getting the right amount of coal burning surface under the boilers is an extremely important one but it is neglected in many cases. The buyer of coal burning equipment is not necessarily informed on the needs of combustion and he reposes his confidence in the equipment manufacturer as to how much grate area is to be installed. The variations in opinions on this detail can be seen from comparing the square feet of heating surface of the boiler to the square feet of grate area in various installations. It will be found that for the same character of coal, this ratio will fall anywhere between 45 and 65. In other words, one square foot of grate surface for every 45 to 65 sq. ft. of heating surface of the boiler will be installed. Truly that is a startling range and if 45 is right, the other figure must be deficient or if 65 gives the proper results, then 45 will be entirely too much grate. Those figures are actual measurements and they prove the inference drawn above that the coal burning equipment is selected to "fit" the boiler, rather than from any reason originating with the type of coal to be burned.

If a boiler is equipped with too little grate area, then it is to be expected that high rates of combustion will follow with the increasing steam demands. This seems to be exactly what occurs in most instances. As soon as high rates of combustion are encountered, that plant will begin to complain about clinker trouble. To get away from that unpleasant condition, the selection of coal must be narrowed down to those fields that produce what is known as high ash-fusing temperature coal. As this temperature of ash fusion goes up, the price does likewise, and premiums will have to be paid for the position the plant has worked itself into. That is because these high ash-fusing temperature coals do not all come from any great variety of locations but rather from specific mines and the freight rate enters as a dominating factor in the final price.

Freight Rates Add to Coal Costs

If the boilers have been equipped with too much grate area, there will be a tendency for inefficient operation due to the excessive amount of air that will naturally pass through the fuel bed. The amount of loss on this account will usually be much greater than the loss occasioned by being compelled to buy coal for which a premium must be paid. Thus it may be seen that the proportioning of boiler size and grate area is an important one, which must be predicated upon the kind of coal that offers the best possibility considering plant location. It would be foolish for a plant in Kentucky to be designed for the use of Pennsylvania low and medium volatile coals, and in the same way, no one would expect a Pennsylvania plant to burn Western coals because either state of affairs would involve cross-hauling of the coal and excessive freight charges. The proportion of grates to boiler capacities varies for these coals so that there is no standard recipe that can be applied to all cases, but each one must be considered on the basis of its individual merits.

Area of grate surface to be installed depends not on the boiler rating but upon the steam that it is called upon to generate. In one Western plant that was built during the past year, the boilers were equipped with 75 sq. ft. of grate surface and their rated capacity is 375 boiler horsepower. At 10 sq. ft. to the boiler horsepower this represents a ratio of 50 to 1 between heating surface and grate area. For the particular coal that was available, this ratio was too low and there would have followed inefficient operation. The loss of heat up the stack would have been great, due to excessive amounts of air; however, the plant load was of such an amount that the boiler delivered 450 boiler horsepower, which made a ratio of 60 to 1, and which changed the entire aspect of the results.

One practice that was prominent after the war, that of buying as second hand, boilers and stokers that were originally purchased for war purposes, is responsible in a large measure for bringing these difficulties to the foreground. There was one instance of this not long ago, which from an engineering standpoint is pathetic. Two boilers equipped with mechanical stokers that had originally been purchased by a concern engaged in the manufacture of war material,

were later taken over by a peace-time industry. In a short time these units were sent to the destination and erected. For a while everything was satisfactory but after a year or two trouble began by the almost continuous clinkering of the coal fed to the furnaces. The boilers were badly under-stokered and the extra plant load, increasing as the salesmen brought in new business, reacted to boost the combustion rate. The resulting furnace temperatures melted down the ash in the coal like slag.

These units had been operated long enough by this time to make it impossible to install more stoking apparatus without practically replacing the stoking equipment under each boiler. An extra long stoker would, of course, add more grate area, but the physical arrangement of the boiler room prevented this. The next and only thing left was to enter the coal market for the purpose of getting high ash fusing temperature coal and to pay the price demanded.

There is a great amount of flexibility in the modern stoker with its multiplicity of wind-boxes, speeds and dampers. This makes for the greatest leeway in adapting the equipment to any set of conditions but it is absolutely necessary that these conditions be known and considered. There never was a time when mechanical equipment was so available for any and all kinds of conditions as is true in the present time, but in the case of boilers, the co-ordination of the mechanical stokers with the boilers must be logical and the start must be with the coal. After that start is made and the plant requirements are investigated, it is an easy task to install enough stoker capacity, or grate area under each boiler to meet these demands.

Cost of Coal Increases with the Plant Restrictions

When this condition exists, the coal buyer will have the greatest possible field to draw upon and every advantage can be taken of the fluctuations in price. Just the minute the coal selection is restricted by a set of plant limitations, then the cost of coal will slowly increase for that plant. The coal market is a bad place to go for aid in solving some problem that is of the plant's making, because the possibility of getting improper fuel is great. Unless information is at hand regarding the quality of a certain coal, it will have to be tried out to determine its adaptability and this is an expensive method. Wherever feasible the plant limitations should be lifted, which is sometimes a difficult task in the case of old boiler installations. There is no reason why the limitations have to be perpetuated and that is the reason for emphasizing care at the time of installing new units or of building a new boiler plant.

Frequently such expressions are heard—"we must burn a 30 per cent volatile coal," or "we have tried high volatile coals and they do not give us good results." The buyer of the coal ought to know positively whether such limitations are legitimate, for otherwise the purchaser will restrict his coal selection unnecessarily and is likely to pay a premium accordingly. The purchaser who makes the statements quoted above will turn around and buy a coal that is represented as containing 4 per cent ash, thinking that a wonderful purchase has been effected, when as a matter of fact the coal that is delivered on this order will average nearer 8 per cent to 10 per cent in ash. Had the coal salesman offered it as an 8 per cent—10 per cent ash coal he probably would not even have obtained an audience.

Industry that contemplates a new boiler plant and applies itself to the task of determining, first of all, what character of coal will be the best fuel for it to consider, has made a decided start in the right direction. Plant location, mine location, railroad connections, market conditions, coal storage space available, are some of the vital factors that enter the discussion at this point. Next comes the realization of the demands that will be placed upon the boilers, in order to know how the boiler sizes must be apportioned and how much grate area will be necessary under each unit to gain the greatest amount of flexibility, so that future growth will be taken care of as it comes along. After that it is time to enter the field of manufacturers to obtain the mechanical equipment that will accomplish the desired results. Once such a plant is in operation, the results will be of the highest and the task of buying coal will not be a wild scramble to get some kind of fuel that will produce satisfaction, but rather an orderly process with a wide field for selection with every opportunity presented to take advantage of price differences in the coal market.

Standard Unit of Wood Refuse

Moisture Content, Physical Shape and Proportions of Different Woods Must Be Considered

WHEN A COMMODITY like wood refuse has attained the position in commerce where it is sold on large contracts and where the value is intrinsically large, a close definition must be made of what is to be delivered. It is obviously impossible in many cases to justify the selling of wood refuse by weight alone. The original establishment of the unit of wood refuse as 200 cu. ft. is unsatisfactory as a quantitative fuel consideration, because the unit was based on the volume equivalent to a cord of wood and is therefore only an approximation. This situation justifies, according to R. J. Gaudy in The Timberman, the establishment of a standard unit which he outlined in the following paragraphs.

When negotiations run into thousands of units, it is obvious that the differentials for superior and inferior qualities and conditions of fuel will amount to sufficient money to justify the careful use of a reference basis. In establishing a standard, the conditions of its use must control, because any elaboration which cannot be carried out on a practical basis with the facilities at hand would only tend to involve the situation and would not contribute to better understanding.

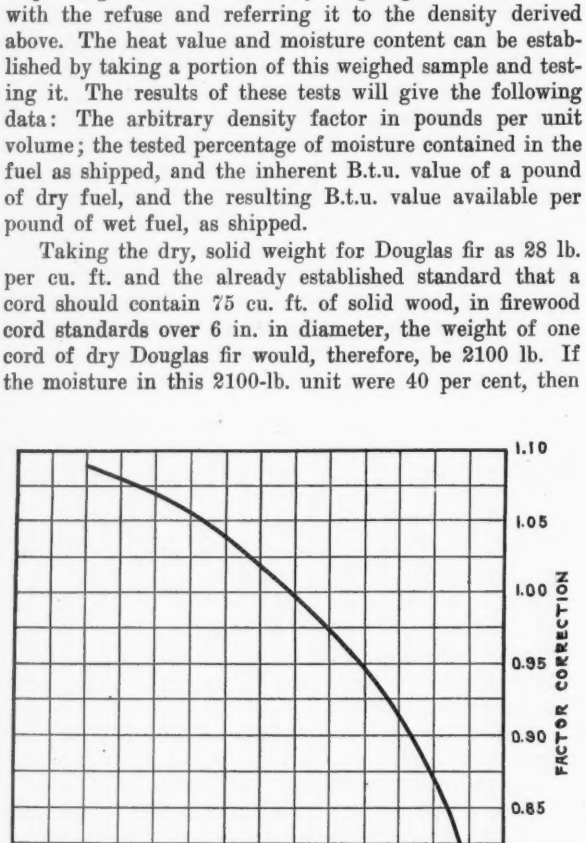
Variables in a unit of 200 cu. ft. of fuel, as loaded, are as follows: (1) The net wood by volume in the 200 cu. ft. may, from inherent moisture or accumulated moisture, have a wide variation in available heat value; (2) Due to the physical shape of the pieces or particles making up the unit volume, the 200 cu. ft. may contain a varying quantity of net wood; and, (3) Due to the proportions of wood from different types of wood making up the refuse, the chemical composition of the wood structure itself will vary, consequently its value as a fuel will also vary.

The unit, therefore, in order to be a standard reference unit, must establish these variables and allow a means of correcting any unit as shipped, to a direct ratio of value to the standard unit quoted. The physical specifications of the Sessions standard unit (S.s.u.) suggested is 200 cu. ft. of wood refuse, weighing 3500 lb., containing 40 per

cent moisture and having an available heat per pound of wet fuel as shipped of 4760 B.t.u.

From a sample of the fuel taken as loaded, the density of packing can be established by weighing a container filled with the refuse and referring it to the density derived above. The heat value and moisture content can be established by taking a portion of this weighed sample and testing it. The results of these tests will give the following data: The arbitrary density factor in pounds per unit volume; the tested percentage of moisture contained in the fuel as shipped, and the inherent B.t.u. value of a pound of dry fuel, and the resulting B.t.u. value available per pound of wet fuel, as shipped.

Taking the dry, solid weight for Douglas fir as 28 lb. per cu. ft. and the already established standard that a cord should contain 75 cu. ft. of solid wood, in firewood cord standards over 6 in. in diameter, the weight of one cord of dry Douglas fir would, therefore, be 2100 lb. If the moisture in this 2100-lb. unit were 40 per cent, then



CORRECTION FACTORS FOR AVAILABLE HEAT PER UNIT OF FUEL

the average weight of the unit would be 3500 lb. This figure again checks the reported average weight of approximately 50 samples of Washington and Oregon hog fuel, which showed an average of 17½ lb. per cu. ft., of 3500 lb. per unit, and an average of 40 per cent moisture.

Four Methods of Stating Heat Value

Heating values of hog fuel are not well understood, and reliable authors, without intending confusion, have reported values varying from 6000 to 9000 B.t.u., all presumably for dry fuel. There are four correct methods of stating the heat values contained in wood fuel, as follows: (1) The inherent heat per pound of dry fuel; (2) The inherent heat per pound of wet fuel; (3) Available heat per pound of wet fuel and (4) Available heat per pound of dry fuel. Careful computation considering average combustion conditions and developed for the four values above, shows that for a pound of fir refuse at 40 per cent moisture, the total heat per pound dry is 8800 B.t.u. The total heat per pound wet is 5280 B.t.u. The available heat per pound wet is 4760 B.t.u. The available heat per pound dry is 7933 B.t.u. Our consideration here and the values which would be dealt with in making and handling the tests are wholly involved in values one and three, the total heat per pound dry and available heat per pound as fired.

The average value which we have taken as our standard of reference is 8800 B.t.u. of total heat per pound dry, which was established from an average of approximately 50 samples of hog fuel, taken in the Northwest. This value is identical with 4760 B.t.u. available heat per pound wet, as fired.

In order to establish the true ratio of value between the unit of fuel as sold and the standard unit (S.s.u.), it is necessary to apply three ratios of correction to the standard unit. The results of test data will show the unit under test to be the following: The standard unit corrected by the ratio of total available heat, which involves the moisture content, further multiplied by the corrective factor of density, and further multiplied by the corrective factor of B.t.u. content or chemical composition.

We will treat the three corrective factors separately. The curve shown herewith gives the direct correction for the moisture content, which is identified as the ratio of available heat. From this curve it is seen that, other things being equal, a unit of fuel, which the laboratory reports as 30 per cent moisture by reading directly above the 30 per cent value to the intercept of the curve, is 103.5 per cent, as valuable as the standard unit.

If a box containing 4 cu. ft. net of the fuel under consideration gives a weight of 20 lb. per cu. ft., then this fuel is inherently denser than the standard unit considered, and is worth 20 divided by 17½ or 114.3 per cent of the standard unit. If, upon the return of information from the laboratory from which the percentage of moisture was also procured, it develops that the fuel sample submitted contained 9000 B.t.u. of total heat per pound of dry fuel, then the unit is over the standard in the inherent fuel value, by the ratio of 9000 to 8800, or the reference basis, which is 102.7 per cent. Therefore, the assumed unit just considered will have, referred to the standard unit, a value as follows:

The standard unit of 100 per cent, enhanced, for example, by being 30 per cent moist to 103.5 per cent, which is further multiplied by the density factor of 114.3 per cent to 118.3 per cent of the standard, which, due to the high heat value, is further increased by the quality factor of 102.7 per cent to a total ratio of 121.5 per cent of the 100 per cent standard unit.

If the quoted price were $1 for a standard unit on board barge, the fuel containing the ratios of discrepancy selected above at random would be worth $1.21½. The ratios selected are in greater divergence from the standard unit than would be expected, but were taken large enough so as to demonstrate readily the influence of the corrective factors.

It is estimated that annual fire waste in the United States is 15,000 lives and $500,000,000 in property. Affiliated with the Insurance Department of the Chamber of Commerce of the United States is the National Fire Waste Council whose grading committee awards citations for distinguished service in fire waste prevention. There are now 359 cities listed in the struggle through their chambers of commerce to reduce fire losses and awards were to be made on March 26 by the committee.

Improved Operation of Stoker Fired Furnace

It Is Interesting to Note How Frequently the Same Mistakes Occur Over and Over Again in the Operation of Stoker Fired Furnaces

CENTRAL STATIONS are, in practically all cases, operated by a corps of trained men and further they are equipped with instruments so that operating conditions can be watched closely. This is not true of most of the smaller isolated plants where the slogan is usually "carry the load" rather than "carry the load economically."

In a recent report by J. F. Barkley, fuel engineer for the Bureau of Mines, is illustrated a typical case of inefficient operation which was readily corrected by the application of proved methods of economical operation.

Two 1000-hp. boilers equipped with multiple retort underfeed stokers were installed in the plant. These boilers were of the horizontal water tube type with horizontal baffling and a high bridgewall at the back. The summer load was about 400 hp. and was carried with one boiler. The winter load of 1250 hp. was carried by the two boilers. No instruments, excepting steam gages, were available for the operator's use. Test No. 1, shown in the accompanying table, was made on one boiler before any alterations had been made. This test was made during the summer time but it is typical of the winter operation.

When the boiler was taken off the line and examined, holes in the baffles were found at the joints of the baffles and water legs. Some one-half tile had been omitted, which permitted short-circuiting of the gases. The boiler setting appeared to be in excellent condition, to ordinary observation. There were no noticeable cracks in the brick work. Leaks existed at the doors and at the joints of boiler and setting. Soot blower nozzles placed at the ends of the boiler had backed out from the holes through the water legs, leaving holes for air leakage.

The main source of excess air, however, was through the stoker itself. It is common practice to let too much air through the lower parts of the stoker. Where the air cannot be controlled by auxiliary dampers, especial care must be taken in keeping the parts properly covered with fuel. It is usually felt that the larger quantity of air burns out the carbon better from the ash, or keeps the ash cooler. Bringing the air needed for the top of the fire through the hot ash is an excellent plan, provided mixing occurs in the furnace. Since some of the air needed above the bed often gets in toward the front of the fire, the amount of air that may be brought in through the lower part of the stoker is limited even when mixing is effected.

Excess Air Must Be Cut Down

Frequently a number of long breaks parallel to the sides of the boiler develop in the fuel bed toward the back. Much flame occurs at these places, and much air gets through. In general, the excess air should be cut down until losses from the formation of CO become too great. The proper adjustments can be made quite closely from the appearance of the fuel bed and flame. Experience can be gained best, perhaps, by taking flue gas analyses for various adjustments until the eye is trained to judge from the appearance of the fire. The knowledge of the CO_2 being produced is an excellent guide in operation. Quite frequently dampers are set and the load varied by varying the air pressure under the stoker and the coal feed. This will give efficient operation for a certain range of loads but will not always handle extreme conditions, especially when they are not set correctly.

Another mistake, particularly in the older furnace settings, is that of not exposing enough water heating surface to the fire. The high bridge wall in the boiler being used as an illustration, permitted only a small part of the lower tubes to "see" the fire. A slanting cut was made across the bridge wall, lowering it somewhat and exposing the entire length of the tubes to most of the fire. Making use of radiant heat direct to water heating surfaces keeps fire temperatures down, giving less trouble from clinkering. This can usually be secured by rearrangement of baffles or change in design of furnace. The baffles should be arranged, if possible, to guide the gases so as to leave no dead tube area.

RESULTS OF LOW-LOAD BOILER TESTS BEFORE AND AFTER IMPROVEMENTS WERE MADE

Test No.		1	2
Duration	hr.	48.00	25.43
Steam pressure by gage	lb. sq.in	81.0	65.6
Force of draft - furnace	in. water	0.21	0.18
- breeching	do	0.27	0.13
Pressure of air at stoker tuyeres	do	0.84	0.12
Temperature of escaping gases leaving boiler	deg.F.	422	315
Total weight of coal as fired	lb.	77,490	29,959
Percentage of moisture in coal as fired	%	1.9	2.5
Total weight of dry ash and refuse	lb.	9394	2426
Total weight of feed water	lb.	663,300	308,772
Total equivalent evaporation from and at 212°	lb.	763,507	357,565
Dry coal per sq.ft. of lower grate surface per hr.	lb.	12.7	9.2
Rated boiler horsepower	hp.	1000	1000
Boiler horsepower developed	hp.	462	408
Percentage of rated capacity developed	%	46.2	40.8
Units of evaporation per lb. of dry coal		10.04	12.24
Analysis of dry gases by volume:			
a. Carbon dioxide (CO_2)	%	6.60	11.45
b. Oxygen (O_2)	%	13.40	7.91
c. Carbon monoxide (CO)	%	0.00	0.06
d. Nitrogen (N_2)	%	80.00	80.58
Lb. dry flue gas per lb. of dry coal	lb.	29.02	17.84
Proximate analysis of coal as fired:			
a. Moisture	%	1.9	2.5
b. Volatile matter	%	22.5	21.4
c. Fixed carbon	%	66.2	69.0
d. Ash	%	9.4	7.1
(Run of mine New River coal)			
B.t.u. per lb. of dry coal		13,874	14,430
Analysis of dry ash and refuse:			
a. Combustible	%	14.7	13.7
b. Ash	%	85.3	86.3
Heat balance, based on dry coal:			
a. Heat absorbed by boiler	%	70.2	82.3
b. Loss due to heat carried away by steam in flue gases	%	4.0	3.4
c. Loss due to heat carried away by dry flue gases	%	16.7	6.8
d. Loss due to carbon monoxide	%	0.0	0.3
e. Loss due to combustible in ash and refuse	%	1.9	1.2
f. Loss due to unconsumed hydrogen, hydrocarbons, to radiation and unaccounted for	%	7.2	6.0
		100.0	100.0

In addition to these few simple changes on the boiler, an ordinary U-tube water manometer was placed to show the pressure of air under the stoker. One was also placed to show the pressure in the furnace. The firemen were trained in the use of the manometers and in the proper appearances of the fire. Test No. 2 was then run under regular operating conditions at the summer load. It will be noted that the air pressure carried under the stoker was only about one-seventh as much as on the first test. It was found possible to carry the winter load at this plant with one boiler. Several tests were made at a winter load of about 110 per cent rating. None of these tests went below 80 per cent efficiency, this being without superheater or economizer.

Deaeration of Boiler Feed Water

BOILER FEED WATER BECOMES OF GREAT IMPORTANCE AS HIGHER RATINGS ARE EXPECTED. BY C. H. S. TUPHOLME

OVERALL EFFICIENCY of a power plant is often considerably affected by the arrangement of the feed circuit. In contrast with the power plants of only a few years ago, this part of the installation assumes more and more importance and the question of feed heating is one which should receive the most careful consideration while the plant layout is still in the preliminary stage.

Any scheme by which this is to be carried out depends upon a number of factors, chief of which is the method of driving the auxiliaries. If operating costs are of primary importance, the majority of the auxiliaries will be motor driven and feed heating will be carried out by means

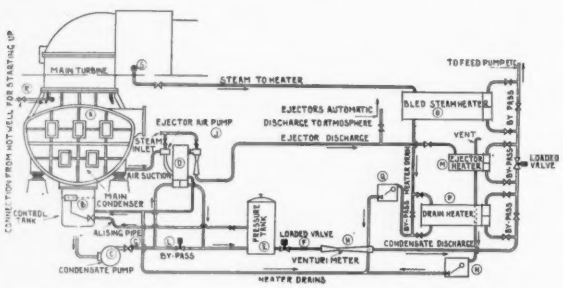


FIG. 1. PRESSURE AND CONTROL TANK SYSTEM FOR A 15,000-KW. STATION

of steam extracted from the lower stages of the main turbine. When reliability is the first consideration, a larger proportion of the auxiliaries will be steam driven and their exhaust steam used for feed heating. Complications are introduced by the use of evaporators, deaerators, economizers and so on, and it may be stated that no system can be laid down here which will meet all cases. Each plant will have its own peculiarities, and the designer's problem is to meet the conditions imposed, at the same time co-ordinating the various auxiliaries with one another and with the main units in such a way as to obtain the best heat balance available in the circumstances—in other words, to produce the maximum number of work units per pound of fuel consumed for the complete plant.

Figure 1 shows diagrammatically a British 15,000-kw. condensing plant embodying a pressure and control tank system, steam jet air extractor with intermediate condenser of the surface type, and with motor operated pumps and bled steam heating. The cycle of operations in this plant is as follows: Condensate from main condenser A falls into the control tank Z. It is withdrawn by the condensate pump C and delivered to the pressure tank E. The pressure in this tank is kept constant by the loaded valve F and is sufficient to deliver the condensate through the feed heating system. To ensure steady running of the condensate pump under all conditions of load, an equalizing pipe G is provided between the pressure and control tanks, the flow through this pipe being regulated by a float valve in the control tank.

The condensate pump is designed for maximum load conditions and continuously delivers the condensate corresponding to this load. When the steam load falls the water level in the control tank is maintained by the float valve which permits water from the pressure tank to return through the equalizing pipe. The quantity passed back is the difference between full load and existing load conditions, so that the amount of condensate discharged from the pressure tank through the Venturi Meter H is the actual steam consumption of the main unit, plus that of the ejector air pump, which is a known quantity.

CONDENSATE USED AS COOLING WATER

Ejector air pump J is of the two stage type with intermediate surface condenser D to condense steam from the first stage. The condensed first stage steam is led to the control tank. The main condensate is used as cooling water, a shunt being taken from the condensate discharge for the purpose. A loaded valve L bypasses the excess over the quantity required to condense the first stage steam.

Steam and air from the second stage of the ejector are discharged to the heater M where the air escapes to the atmosphere. The condensed second stage steam is led to the control tank via the trap N. A bypass similar to that on the intermediate condenser D is provided on the heater M. The main feed heater O is supplied with steam taken from a low pressure stage S of the turbine. The condensed steam from the heater is taken to the drain-heater P in which a portion of its sensible heat is extracted. The cooled water is led to the control tank through the drain trap Q.

For starting up the plant it is necessary to obtain a supply of cooling water for the intermediate condenser on

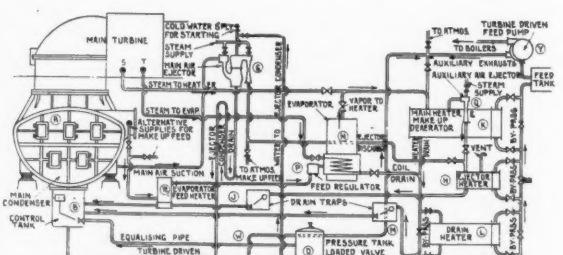


FIG. 2. THIS SCHEME IS SIMILAR TO THAT SHOWN IN FIG. 1 EXCEPT THAT IT INCLUDES AN EVAPORATOR

the ejector air pump. A connection from the hotwell is provided for this purpose through R. Such an arrangement as that shown would of course be modified to suit other plants.

Figure 2 is another plant with somewhat similar layout; but it includes an evaporator, turbine driven pumps, and steam jet air extractor with intermediate condenser of the water jet type. The operating cycle is as in Fig. 1, but is amplified as follows to suit the additional units:

Make up feed water is introduced to the system through the evaporator N. The make up may be taken from the main condenser circulating water or alternatively from any other outside source available. On its way to the evaporator the make-up water passes through the heater R in which it takes up some of the sensible heat in the drain from the ejector heater H. The float regulator P maintains a con-

stant water level in the evaporator. The vapor from the evaporator is led to the main heater K where it is condensed and the contained air drawn off by the auxiliary ejector air pump Q. This ejector discharges into the same heater H as the main air pumps. The evaporator is operated at a pressure corresponding to that at which steam is bled from the main unit to the heater K, the steam supply to the evaporator being taken from another stage T of the main unit at a higher pressure. The exhaust steam from the auxiliaries may be used in the evaporator and other modifications have been introduced to suit other plants.

Another development which has become of importance in recent years is the deaeration of the feed water. Due partly to the use of steel tube economizers and partly to the greater intensity at which boilers are now operated, corrosion troubles have increased. It is now definitely accepted that where the feed water itself is not inherently acid, the corrosion is due to the presence of oxygen. There is always a certain proportion of oxygen in the condensate leaving the condenser which may or may not be sufficient to cause trouble, depending principally on the efficacy of the air removal apparatus, and the condenser design as a whole. In most plants, however, especially in those having an open hotwell, this oxygen is considerably augmented by the time it reaches the boilers and if trouble is to be avoided some form of deaerating apparatus is necessary.

Deaerators of the type shown in Fig. 3 are growing in popularity among British plants. The basis of their design is the following facts: 1. The solubility of dissolved gases in water is always reduced by an increase in temperature, 2. The rapid injection of hot water into a chamber wherein is maintained a lower boiling temperature results in a disruption of the water particles during which any contained gases are thrown off. The apparatus shown diagrammatically in Fig. 3 consists essentially of a deaerator A, a feed water heater B, a vapor condenser C, ejector air pump D and an ejector condenser E. In this design the two condensers are of the surface type, the feed water passing through the tubes and absorbing heat from the surrounding steam or vapor. The heater is of the direct contact type working at about atmospheric pressure and is provided with a vent W, through which escapes any air liberated during the process. Feed water from the hotwell pump enters the apparatus at F, and passing through E, C and B in series is heated to the desired temperature. It is then introduced to the deaerator A in which the ejector air pump D maintains a pressure somewhat below that corresponding to the temperature of the entering water.

Operation of the Deaerator

Action on the hot feed is spontaneous. A proportion of the water flashes into steam and causes the contained air and gases to be thrown off. The effect is accentuated by a system of perforated trays in the deaerator which subjects the water to a further disintegrating process. The deaerated feed then passes to the boiler feed pump by the pipe G. The vapor thrown off in the deaerator passes into the vapor condenser C in which it is condensed and drained back to the deaerator, while the air and gases are taken by the ejector air pump D and discharged to the atmosphere through the vent H on the ejector condenser E. In this condenser the steam used by the ejector is condensed and drained at V to the hotwell. S is the steam supply to the ejector and T a non-return valve. The quantity of water passing through the apparatus is regulated to suit the requirements of the boiler feed pump by means of float controlled valves J and K. The admission of heating steam is also regulated by the thermostatic control R to give the designed operating temperature. This steam is usually taken from the low pressure source L. An alternative connection for high pressure steam M is shown, N being a reducing valve and P a non-return valve. The various connections can be arranged to suit the requirements of individual plants.

In certain circumstances, as for instance when the auxiliary exhaust available is of an oily nature, a surface heater may be advisable. It will be appreciated, of course, that a heater as such is not an integral part of the deaerator; and if the feed water is already at a sufficiently high temperature to give effective deaeration (as is the case in the plants shown in Figs. 1 and 2), only a deaerating chamber and vapor condenser would be necessary, with the usual provision for air extraction. In most cases the deaerator would be supplied by a hotwell pump drawing from the hotwell; but in cases where the condenser extraction pumps discharge through a system of heaters in combination with a head or surge tank, this extra pump would not be required.

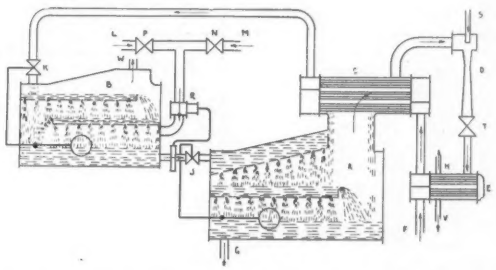


FIG. 3. SCHEME OF DEAERATOR WHICH IS OFTEN USED IN BRITISH PLANTS

Burning Iron Under Water

RECENTLY there has been developed a method of cutting steel under water. The equipment used is known as an electro-gas burning torch. It consists essentially of a flat carbon electrode with two holes through its center. This electrode is set in a combination holder which connects the carbon to the electric lead wire and the holes with a gas hose, both of which come down to the diver's position in a single manifold. This with the diver's life line and air hose completes his underwater equipment. A generator supplies current for the torch and tanks of oxygen furnish the gas. The diver dictates his wants to his helpers by signals through the life line and these men supply his needs.

Cutting action of this torch where gas and electricity are used in combination, is this: first an arc is struck by touching the end of the electrode to the point at which the cutting is to be done. Then the carbon is quickly pulled away until there remains a long electric arc between the end of the electrode and the metal.

In the water, the result of this electric arc is a pocket or globe of water vapor around the arc so that the oxygen gas which flows through the pipes in the carbon to the tip is forced through a vapor area and directly at the metal to be burned.—Current News.

Fitting Evaporators to the Heat Balance

To Convert Heat Into Work It Is Necessary to Degrade Part of the Heat to a Lower Temperature and Reject It. By Robert D. Spear

EVAPORATORS require heat in the form of steam for their operation. The steam used should, if possible, be such that it cannot be economically used for other purposes. The selection of the type of evaporator for producing boiler feed make-up is therefore dictated largely by the power plant heat balance. That evaporator should be selected which, other conditions being equal, fits in best with the arrangement for heating the feed water, causing neither loss of heat nor availability.

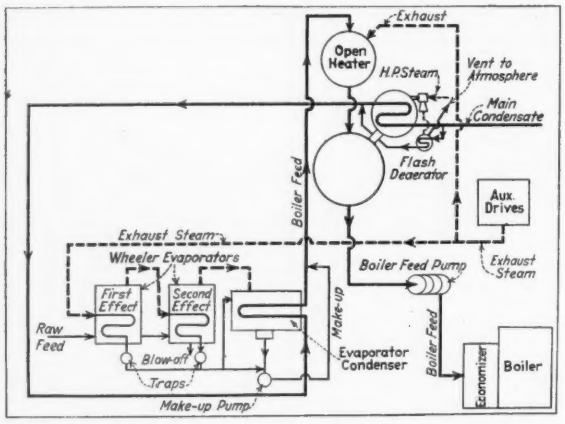


FIG. 1. FEED WATER HEATING DIAGRAM FOR DELAWARE STATION, PHILADELPHIA ELECTRIC CO.

In different plants the evaporators may fit into the heat balance best as high, low or medium operating pressures. High pressure evaporators using steam at or near boiler pressure, sometimes called "high heat level" evaporators, fit in well in stations where, owing to the absence of economizers, there is ample temperature drop available between boiler temperature and the highest temperature to which the boiler feed is heated by extracted or exhaust steam. They will produce distilled water and heat the boiler feed to a higher temperature than it would otherwise attain at no more loss of availability than if the heating of the condensate were completed by high temperature heat in the boiler itself. High pressure evaporators, due to the dense vapor, require only small steam passages, but must be constructed for high pressures. Frequently boiler pressure is thought too high for evaporator use and the steam is throttled in a reducing valve with consequent loss in efficiency. High level operation gives more trouble from scaling than does low level operation, as calcium sulphate and other scale-forming solids are much less soluble at high temperatures than at low temperatures. The blow down is greater and higher in temperature than in low pressure operation. At high temperatures radiation losses, which increase as the fourth power of the temperature, and convection losses, which increase directly as the temperature, are large.

Low pressure evaporators, that is, those taking steam at from a few pounds gage to 20 in. vacuum and producing vapor under a considerable vacuum, have many advantages. They scale little and the scale which does form is soft and easily removed by temperature cracking. Radiation losses are negligible, as the temperature of the evaporator is little above that of its surroundings. Blow-down losses are low, because of both the small amount of blow necessary and its low temperature. Low pressure evaporators fit in well with economizers. Since there is generally enough heat in the flue gas from the average boiler to heat the boiler feed from 210 deg. F. to boiler temperature, it is usually wasteful to heat the feed much above 210 deg. by other methods. If the evaporator is under vacuum, no evaporator feed pump is needed. Vacuum may be maintained without a separate vacuum pump by venting the evaporator condenser to the main condenser.

Medium pressure evaporators, working with the vapor space under about atmospheric pressure, combine many of the qualities of both high and low pressure evaporators. To a film type evaporator medium pressure operation offers no great advantages over low level operation, but with submerged tube evaporators it offers the least operating difficulty from priming and reduces the loss from

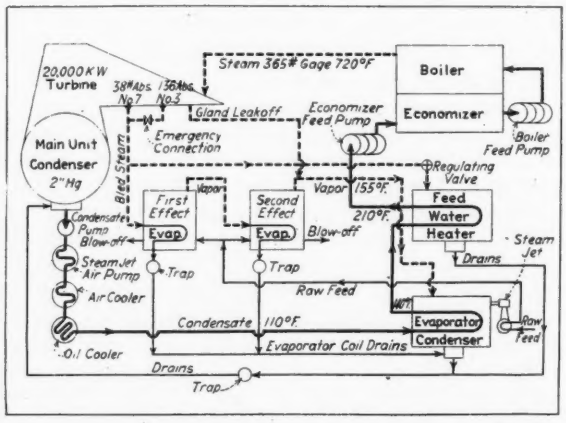


FIG. 2. DIAGRAM FOR THE HALES BAR STATION, TENNESSEE ELECTRIC POWER CO.

hydrostatic head. Medium pressure evaporators may exhaust to a deaerator or open heater, thus saving the cost of an evaporator condenser.

Three Methods for Heating Water

Exhaust steam from auxiliaries, bled steam from the main turbines and economizers, the three commonly used means of heating boiler feed water, are to some extent complementary and may be combined in many different ways with make-up evaporators. From an efficiency standpoint it is desirable to run the auxiliaries electrically from the main unit. To insure continuity of operation in case the main generator or turbine should be temporarily disabled, it is advisable to have the more important auxiliaries, such as the boiler feed pump and the condenser circulating pump, independently driven. A compromise is often made by installing a house turbine which produces power nearly as efficiently as does the main unit, but is electrically independent.

A diagrammatic representation of a station using low heat level evaporators with open deaerating heaters and

economizers, the Delaware Plant of the Philadelphia Electric Co., is shown in Fig. 1. A similar arrangement is now being installed in the new Chester Station of the same company. The evaporator has two effects and uses as the heating medium exhaust steam from the auxiliary drives at less than atmospheric pressure. The condensate is pumped from the main condenser hot well to the condenser of the flash type deaerator, then through the evaporator condenser and from there to the flash type deaerator. The deaerator takes exhaust steam from the same source as the double effect evaporator. The heating of the condensate is completed in economizers. All the heat in the exhaust steam is absorbed by the condensate without any loss of availability.

Often all the auxiliaries are driven electrically, and the feed water is heated first by bled steam and then by economizers. Present day practice calls for a definite relation between the boiler pressure, the number of bleed points and the bleed temperatures at rated turbine loads. With a steam pressure of 300 lb. ga. and economizers having about 60 per cent of boiler heating surface, if only one stage of bleeding is used, its temperature may be about 220 deg. F.

At the Hales Bar Station of the Tennessee Electric Power Co., the condensate, after going through miscellaneous small heaters, flows first to the evaporator condenser and then through an open heater taking steam from the seventh stage. From here it is pumped to the economizer. The evaporator is double effect, there being a separate first effect for each of the two main units. Vapor from the first effect goes to a single large second effect. Steam for the evaporator is normally taken from the seventh stage at 38 lb. absolute, but steam at 136 lb. absolute can be bled from the third stage to give excess capacity or for temperature cracking.

Another scheme of heat balance is that in which the boiler feed water is heated entirely by bled steam, and the loss of heat in the flue gas is either avoided by using a "high" boiler or is recovered by an air preheater. With about 300 lb. boiler pressure (417 deg. F.), if one bleed point is used, its temperature may be around 260 deg. F., and an evaporator and evaporator condenser can be installed between this point and the condenser temperature without any loss of availability. If two bleed points are used, steam is generally taken about 200 deg. F., and 300 deg. F., leaving about 100 deg. F. between the condenser temperature and the first bleed point. This is generally considered ample to operate a film type evaporator with its condenser. If three bleed points are used, the steam temperatures are about 170 deg. F., 240 deg. F., and 310 deg. F., and if four bleed points are used, 150 deg. F., 210 deg. F., 270 deg. F., and 330 deg. F. In the latter case an evaporator taking steam from one stage and using the next lower heater as its condenser gives flexibility of operation at the cost of a very slight loss in thermodynamic efficiency. This loss can be disregarded in a modern power station, where the make-up is only about 3 per cent, as with a double effect unit the evaporator would take only about 1.75 per cent of the total steam.

In the Seal Beach Station of the Los Angeles Gas & Electric Corp., the condensate, after flowing through a number of small heaters, is heated in series in four surface heaters using stage bled steam. The single effect evaporator takes steam at 58 lb. absolute from the same source as the third heater, and uses the second heater at 14.5 lb. absolute as the evaporator condenser. Steam at 170 lb. absolute from the same stage as that used in the fourth bleeder heater can be used for cracking scale. It is noteworthy in this station that the feed is heated to within 90 deg. of the boiler temperature; the various bleed points are about 80 deg. apart.

The make-up requirements in power plants do not vary in direct relation to the load, but at part loads the loss will be a large percentage of the total steam generated than at full load. Evaporators, therefore, must be designed to take care of the station load at part loads as well as at full load.

If a single effect evaporator and evaporator condenser normally operating over a 100 deg. drop requires a 30 deg. rise in its condenser, leaving a 70 deg. drop in the

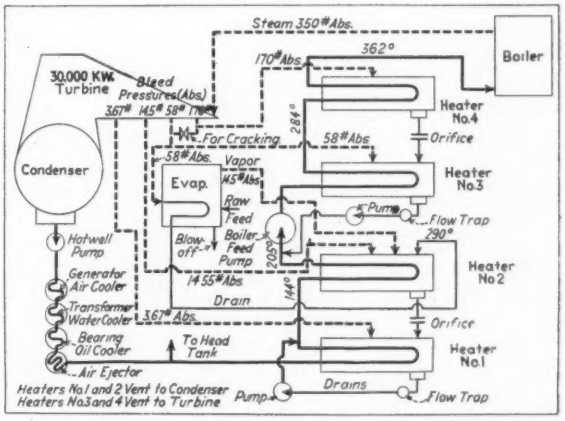


FIG. 3. FEED WATER HEATING DIAGRAM FOR SEAL BEACH STATION, LOS ANGELES GAS AND ELECTRIC CO.

evaporator proper, is run at half load, a 60 deg. rise in the condenser will be needed to produce the same amount of distilled water, leaving only 40 deg. over the evaporator. As, of course, the evaporator will not be required to produce quite as much water as would be the case at full load, the rise in the evaporator condenser will not be great and the effect will not be so marked. It has been found advisable, however, to design single effect evaporators to have full rated capacity at three quarters of full load. The double effect evaporator working under the same conditions, on the other hand, will require at full load only 15 deg. rise in its condenser and at half load, to produce the same amount of condensate, 30 deg. rise, cutting the effective temperature drop from 85 deg. to 70 deg. This does not cause a serious reduction in capacity and it has been found that double effect evaporators designed for full load conditions will produce ample make-up at fractional loads.

Many stations which have a good power factor and do not need to be run at part load for long periods of time supply the additional capacity needed at partial loads by taking the steam for the evaporator from a higher bleed point in the turbine. A connection for this purpose can be seen in both the Hales Bar Station and the Seal Beach Station before mentioned. Some stations with a large temperature drop between boiler temperature and the highest bleed point or its equivalent, use a high pressure evaporator, and at full load supply it with boiler steam through a reducing valve. At part load the capacity is obtained by admitting full boiler pressure to the evaporator.

Method of Starting a Turbo-Generator

By J. B. Petrie

UPON NUMEROUS occasions I have seen printed instructions on how to start a turbine when it is cold. These aroused my curiosity so I asked one of our operating engineers to describe the procedure followed in putting one of our turbo-alternators on the line. All of our condenser auxiliaries are steam driven. We use salt water for condensing and are confronted with a tide fall of about 5 ft.

The method described to me is as follows: owing to the amount of time taken to prime the circulating pump, we begin by flooding the condenser and pump. This is done through a 1½-in. pipe connected from the main water supply to the top of the condenser. This method is used in preference to using the suction tee supplied with the pump because it is less tedious, especially when the tide is low. The air lock on the top of the pump is opened to expel the air, then we open the valve on the discharge and while the system is filling open the exhaust valves and drips of the circulating and condensate turbines and also see that the oil wells and turbo gears have a full supply of oil. The water seal is then put on the pump packing.

When water issues from the air cock, the circulating turbine throttle valve is cracked open enough to run the machine about 150 r.p.m. We then make sure that oil circulation is established in the turbo-gear casing and that all oil rings are moving. The valve on the pump discharge is then closed to about three-quarters shut to reduce the load on the turbine while bringing it to speed and then we bring the machine up to speed. The valve on the discharge is then opened and the priming valve and drips are closed.

If everything runs well and water circulation is established, we start the condensate pump which is done in the same manner as starting the circulating pump except that priming is not necessary because there is a head on the suction, the condenser being above the pump. One Radojet is put in operation and the vacuum is not allowed to go too high, say 10 or 15 in. To keep it within this range, we open or close the relief valve on the first stage, which is controlled by a hand wheel near the throttle of the main machine. This is essential as turbines are inclined to overspeed when exhausting in high vacuum with no load.

We then open the drips outside the main throttle valve; oil the main governor transmission knuckles and pins on the valve operating mechanism and turn on the water for cooling the bearings. We next oil all connecting rods, knuckles and pins between the butterfly valve and the emergency governor; then latch open the butterfly valve and use the hand trip to make sure it functions properly. Finally we latch it open again, and then the turbo-generator is ready to start which is done by cracking open the main throttle valve and admitting enough steam to run the machine up to about 300 r.p.m. We let it run a short while at this speed to give the turbine a uniform temperature.

While the machine is warming, we inspect the oil circulation, and see that the pump is delivering oil to the journals governor, worm and thrust cage. When the machine is warm, the drips may be partly closed and the machine brought up to speed quickly but with continuous acceleration. Finally the drips are closed.

While the machine is coming up to speed, we watch the governor closely and make sure it starts to operate from one to three per cent below normal speed and that the valves close one by one until the no-load high-speed valve is reached.

When the unit is up to speed, we see that the resistance in the alternator field is all in; close the field switch and the switches on the regulator corresponding to this machine; adjust the excitor field rheostat to the point determined when installing the regulator and then close the exciter main switch. The alternator rheostat is then gradually turned until the proper voltage is indicated and when the machine is in synchronism the main switch is closed.

The steam seal is then put on the turbine carbon packing, the remaining Radojet put in operation, the first stage relief valve closed and the water seal put on the last stage relief valve. The machine can then be made to take its proportionate share of the load by increasing or decreasing the tension on the governor spring. The spring is operated by a series motor with double field winding and is controlled at the switchboard with a double-pole, double-throw reversing switch. The amount of travel is limited to 2½ per cent increase or decrease of speed by a limit switch attached to the spring.

Changes in the Electrical Industry

Revolutionary changes in the electric light and power industry in the last few years are pictured by M. S. Sloan, President, the Brooklyn Edison Co. and chairman of the public relations section of the National Electric Light Association.

Mr. Sloan's statement is in the nature of a corrective of the danger which the electric industry faces in common with all American business, the danger of outrunning public understanding.

"The public must be given the oportunity to understand the intricate workings of business, and the goals to which business men look," Mr. Sloan continued.

"The electric light and power industry has made remarkable progress in the last ten years. The developments in our industry which were considered startling ten years ago are today nearly forgotten because of revolutionary changes.

"In 1924 the output of our companies exceeded fifty billion kilowatt-hours. During 1924, more than $1,000,000,000 of new capital was raised from the investing public for additions and expansions. That is more money than the steam railroads raised during that period."

With all that progress, Mr. Sloan invited attention to the fact that the cost of current has decreased 8.6 per cent since 1913, although other items in the family budget showed an average increase of 70 per cent over pre-war prices.

"The fact that the per capita use of electricity has greatly increased is the best evidence that rates are reasonable," Mr. Sloan said. "The additional fact that approximately 2,000,000 new customers were attached to the lines of our companies during 1924, is the best evidence that the cost of electricity is within the reach of everyone."

An extremely important factor in the installation of pipe lines is the proper hanging and anchoring of the lines. Vibration and movement in pipe lines cause leaky joints and breaks in the lines.

Importance of Belt Thickness in Computations

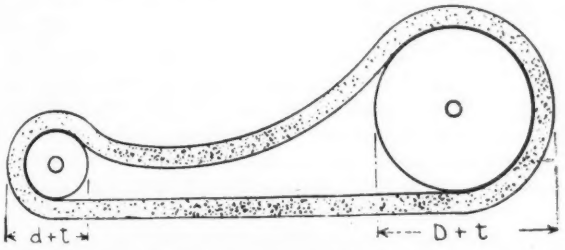
By W. F. Schaphorst

I HAVE HEARD it argued that belts don't slip as much as we think. A certain gentleman put a belt on a 4-in. driving pulley and made it drive a 40-in. pulley. The small driving pulley made 1000 r.p.m. He therefore figured that the speed of the large pulley should be 100 r.p.m. because $1/10 \times 1000 = 100$. The ratio of 4 to 40 is the same as 1 to 10, you see. It seems like a simple thing to figure, doesn't it?

Imagine this gentleman's surprise, however, when he found that the driven pulley ran at a speed of a trifle over 105 r.p.m. instead of 100, and when fully loaded its speed was 103 r.p.m.

"How does it do it?" he asked. "Instead of slipping or losing speed on account of belt stretch it actually gains speed on me."

So, as a matter of experiment, he reversed the drive, making the large pulley the driver and running it at 100



WHEN CALCULATING PULLEY SPEEDS THE THICKNESS OF THE BELT MUST BE CONSIDERED

r.p.m. He figured, as is ordinarily done, that the speed of the small pulley should be 1000 r.p.m. But, lo and behold, he could get only 948 r.p.m. out of the small pulley even when no load was being transmitted. When the belt was stressed by a load, the best he could get out of the small pulley was 929 r.p.m.

"This is terrible," he declared. "What's wrong?"

Thereupon this gentleman "got busy" and started reading what he could find on the subject of belt transmission. He bought a book and studied it carefully but no good did it do him. He found this parallel problem in Cromwell's "Belts and Pulleys":

"The diameter of two pulleys which are connected by one and the same belt, are D 30 in. and d 10 in.; the larger pulley makes N = 120 r.p.m. It is required to determine the number of revolutions per minute of the smaller pulley. From the formula we have:

$$\frac{N}{n} = \frac{d}{D} \text{ or } \frac{120}{n} = \frac{10}{30}$$

From this, n = 360."

"By crackie!" ejaculated the gentleman, "that's just the way I worked my problem, but it doesn't come out right in practice."

He looked into manufacturers' catalogs, also, but found no help until he took his troubles to a friend who is an old hand at the belt transmission game and this friend at once told him that the trouble lay in the fact that the thickness of the belt was not taken into consideration. "You must always add the thickness of the belt to the pulley diameter in the formulas," counseled the friend.

Thereupon the gentleman made this formula out of the one that appears in Cromwell's "Belts and Pulleys":

$$\frac{N}{n} = \frac{d+t}{D+t}$$

Where N = r.p.m. of the large pulley;
n = r.p.m. of the small pulley;
D = diameter of the large pulley in inches;
d = diameter of the small pulley in inches;
t = thickness of the belt in inches.

He substituted his values, which I have already given, in this formula and sure enough he got 105 as a result when the small pulley was used as the driver and 948 when the large pulley, as the driving pulley, ran at 100 r.p.m. The thickness of his belt was ¼ in.

In order to impress this point more forcibly on the reader's mind, I have therefore made this sketch in an exaggerated way. It shows just how pulley diameters should be measured—including the thickness of the belt—and also shows why a thick belt will "fool" the ordinary layman more quickly than will a thin one. If a belt didn't have any thickness at all, then, and only then, the formula as given in Cromwell's book would be correct.

Now, coming back to my first sentence, I have heard it argued that belts don't slip as much as we think on account of this influence of belt thickness. That, however, is not true. Belts do slip and it is a pretty safe bet that they always will to some extent.

It is a simple matter to compute belt slip even when taking belt thickness into consideration. This is done by using this gentleman's correct formula as a basis and as a result we have this formula:

$S = R\ (D + t) - r\ (d + t)$ = total belt slip per minute in inches.

Where R = r.p.m. of the driving pulley;
r = r.p.m. of the driven pulley;
D = diameter of driving pulley, inches;
d = diameter of driven pulley, inches;
t = thickness of belt, inches.

Now, if you want to compute the horsepower lost, due to belt slip, use this formula:

$$\text{hp.} = \frac{\text{HP.} \times S}{R\ (D + t)}$$

Where HP. is the horsepower of the engine or motor given to the driving pulley.

If you will apply these correct formulas to your belt drives, you will surely find that every belt that pulls any load at all is slipping to some extent. There is a power loss in every working belt due to either slip or creep. If there is no slip there certainly is creep.

Creep is due entirely to the elasticity in the belt and is unavoidable, so, if you find that you are losing about 2 per cent of your power through use of the foregoing formulas and if the belts are heavily stressed, you can safely attribute the loss to creep. But if you get a result greater than 2 per cent, you can generally be sure that something is wrong and power is needlessly going to waste.

A belt that is transmitting power is tighter on one side than on the other. The belt naturally has to adjust itself as it goes around the pulley to make up for this difference in length. Hence we have unavoidable action known as "belt creep."

Clean Fuel Oil Improves Diesel Operation

CENTRIFUGAL TREATMENT REMOVES SOLID MATTER AND WATER. TESTS SHOW IMPROVED OPERATION WITH CLARIFIED FUEL

RECENT SURVEYS conducted among oil engine users have shown that oils most widely used for fuel are within the range of 24 and 36 deg. Be. The viscosities of these Diesel fuels is sufficiently low to permit gravity sedimentation of a large part of the water and solid impurities while the oils are in storage tanks. Various filters have been employed, with some success, to remove impurities that do not settle by gravity. Even where it is necessary to heat the oil to obtain satisfactory purification, moderate temperatures are sufficient.

There is an increasing movement to use heavier fuels, principally because they are cheaper. Furthermore, it is

FIG. 1. AIR-TIGHT COVER ON CENTRIFUGE PREVENTS ESCAPE OF GASES FROM HEATED OIL

highly desirable that a Diesel be able to burn any fuel that may be produced; the lighter oils are not always available in the market. The latter point is of particular concern to the motor ship, which should be able to use whatever grade of oil is procurable at the ports it touches. The heavier fuels are the ones usually available, therefore the Diesel ship that is compelled to burn only lighter oils is frequently forced to carry a large oil supply and so sacrifices cargo space.

There are, however, certain objections to the use of the heavier oils for Diesel engines. The difficulties encountered in burning such oils in Diesel engines may be divided into four classes:

(1) Difficulties in handling oils that are viscous at normal temperatures.

(2) Ignition difficulties.

(3) Difficulties in burning oil after ignition.

(4) Difficulties caused by the presence of small quantities of impurities.

Difficulties listed in the first three classes can and are being overcome by the proper design of engines and of their fuel storage and handling systems. The difficulties encountered from impurities in the oil burned cannot be overcome in the same manner. The elimination of impurities constitutes an entirely separate problem, although many troubles caused by poor design have been wrongly attributed to foreign matter in the heavy oils.

Great strides have been made recently in producing Diesels that are mechanically capable of burning heavy oils. It is safe to say that the majority of engines now being put in service are adapted to burn the heavier fuels if such fuels are purified before use. The same is not true of some types of engines, particularly those of older design, and it is illogical to expect an engine not designed for them to operate effectively upon heavy oils, even though the oils are well purified.

EFFECT OF CENTRIFUGAL TREATMENT OF DIESEL FUEL

It has been found possible to improve materially the quality of various grades of fuel oil used for Diesel engines by running them through a centrifuge before they are burned. The centrifuge removes suspended solid material consisting of dirt (soil), tank scale and insoluble asphaltic or carbonaceous material. If water is present, it is removed at the same time. The net result of the centrifugal treatment is the production of oils that burn freely in the engine, that may be used without causing excessive wear on the cylinder liners and pistons and that burn without misfiring.

It is generally believed that there is little objection to using oil of .02 per cent ash content for Diesel fuel, which is about the average for first grade Diesel oil of 27—29 deg. Be. It is not true, however, that even first grade Diesel oil will have an ash content so low as this, and a centrifugal treatment of this light oil is of great value in reducing high ash.

Where heavier fuels are to be used, it is essential that a means be provided for reducing the ash content before burning the oil, because these oils invariably contain a that will form ash when the oil is burned. This ash in relatively high percentage of non-combustible material the cylinders causes wear on liners and pistons, and in extreme cases interferes with proper operation of valves.

Most ash exists in the oil as solid suspended matter, such as dirt and tank scale, associated with insoluble asphaltic material. An additional source of ash is any water present, which invariably contains a considerable concentration of inorganic salts. When the water vaporizes and passes off in the exhaust from the engine, a portion of these salts remains behind in the cylinders.

To illustrate the reduction in impurities achieved by centrifuging, the following typical analyses are given for the water and ash content of four oils before and after treatment.

Oil No. 3 was used in a new engine of 2500 hp., running over 5 mo. continuously, 6 or 7 hr. per day, six days per week. The oil was heated to 160 deg. F. before cen-

trifuging. At the end of the test period the engine was dismantled and thoroughly examined and calibrated for wear on liners. None could be detected up to 0.0001 in. In fact, some of the tool marks on the liners were not removed.

Oil Gravity	Ash, per cent		Water per cent	
Deg. Be.	Before	After	Before	After
29	.027	.020	Trace	Nil
26	.102	.007	2.6	Trace
17	.065	.021	8.0	.5
17	.077	.040	0.1	Nil

In a run on a measured 5000 lb. of this oil, 8¼ lb. of solid matter were taken out by the centrifugal. This solid matter tested 5 per cent of non-combustible.

Heat Aids Removal of Dirt from Oil

In order to effect an entirely satisfactory purification of fuel oils for Diesel engines, it is necessary to heat them before centrifuging, except in the case of very light oils. The temperature used before centrifuging depends on the viscosity of the oil and the extent to which this viscosity must be reduced before satisfactory results can be obtained by centrifugal treatment. To centrifuge an oil with a gravity in the neighborhood of 30 deg. Be., a temperature of approximately 120 deg. F. is usually sufficient. To handle oils of a gravity in the neighborhood of 20 deg. Be. and below, it is highly desirable that temperatures ranging up to 210 deg. F. be obtained. A temperature of about 150 deg. F. is often close to, if not above, the flash point of many of these oils and one of the chief difficulties previously encountered has been the danger from escaping fumes developed when heavy oils are heated sufficiently hot for satisfactory centrifugal treatment. This is, of course, a serious disadvantage on shipboard.

As a result, the maximum efficiency has not been obtained in using the open type centrifugal on heavy fuels, since it has been compulsory to operate with oil at temperatures below that necessary for the best results.

To overcome the temperature limitations imposed upon treatment of fuel oil with the open machine, a machine has been designed in which the centrifugal operation is carried out in a totally enclosed "frame" or housing within which the centrifugal bowl rotates. This frame is built to withstand any pressure that may be developed by gases from hot oil. No gases may leak from the machine to constitute a fire hazard. With this machine it is possible to centrifuge heavy oils at the temperature necessary to procure a satisfactory reduction in the ash and water content. Oil may be centrifuged at a temperature up to and above 200 deg. F. normally well above the flash point of the fuel oils, if that is required to secure a satisfactory fuel.

Centrifuge Is Tested with Three Oils

Some recent tests of a Presurtite Sharples Super Centrifuge, designed for the centrifugal treatment just described, are recorded in the accompanying table. These tests were made with three different fuel oils, which, after passing through the Super Centrifuge, were fed directly to a single-cylinder, double-acting Worthington Diesel engine.

This engine is of the two-cycle type, with a cylinder of 27-in. bore and 40-in. stroke, with air injection, using air at 600 lb. pressure and cylinder compression of 450 lb. The quoted oil consumption of this engine was 0.43 lb. per hp. hr.; this is about 40 g. p. hr., with the engine rated at 750 hp. and running at 90 r.p.m. On the tests recorded here, the consumption varied from 43 to 53 g. p. hr. The exact horsepower on the water brake was not given, but was approximately 800 hp.

In this test, fuel oil flowed first by gravity through heated strainers to a scale tank beside the engine fuel pump. In installing the centrifuge, this unit was mounted on the same deck with the strainer and fuel tank. A steam jacketed heater and small air-driven, duplex, piston pump were installed to heat the oil further and to feed this hot oil to the Super Centrifuge. The centrifuge discharge was delivered to the top of a 6-in. jacketed stand-pipe 7 ft. long and the engine fuel pumps drew from the bottom of this stand pipe. As the stand pipe capacity was only 15 gal., an overflow was connected so that the centrifuge operator could be sure that this was full. Data on each run are shown in the table; the following notes refer only to the outstanding incidents of each run.

Comments on Tabulated Test Results

Run 1—Oil A. It quickly developed, by the end of the first hour's operation, that the stand-pipe arrangement for

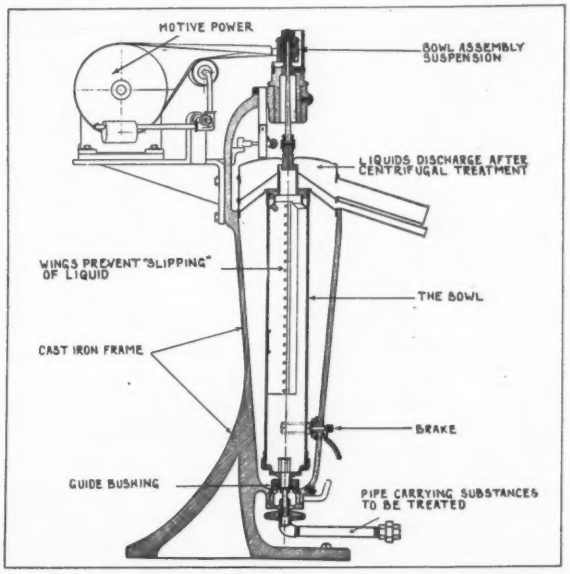


FIG. 2. INTERNAL CONSTRUCTION OF CENTRIFUGE, SHOWING BOWL AND BOWL SUSPENSION

feeding the engine fuel pumps was not large enough to handle properly the discharge from the centrifuge. The engine was shut down and prompt steps taken to install a closed and vented 150-gal. tank to receive oil from the centrifuge and deliver this to the engine fuel pumps free from air.

Run 2—Oil A. As soon as the tank was ready, the centrifuge was started and operated for two hours to fill the new engine tank to operating level. Changes in pipe lines, vent lines and engine inspection delayed engine operation until the following Monday.

Run 3—Oil A. Tests were conducted all day with no trouble of any kind, the engine developing full power, with clean exhaust and no misfiring. No water was discharged from this oil but the centrifuge removed 4.6 oz. of sand and dirt per 100 gal. of fuel.

Run 4—Oil A. Oil was centrifuged at a higher temperature, 200 deg. F. The solids increased to 5 oz. per 100 gal., although the increase consisted of the more

gummy, finely-divided, carbonaceous material rather than an increased quantity of sand.

Runs 5 and 6—Oil B. The Super Centrifuge was adjusted to meet the change from 16 deg. Bé. to 11.8 deg. Bé. oil. It was found necessary to go no higher than a temperature of 170 deg. F. for heating the oil before centrifuging. A temperature of 180 deg. F. caused the formation of gases in the oil and prevented proper operation of the pump supplying the centrifuge.

The amount of solid impurities removed from this oil was approximately one-half that removed from oil A; however, water was found present in this oil, evidently in pockets, judging from the irregular manner in which it came from the centrifuge.

Operation of the engine on the centrifuged fuel was entirely without misfiring or otherwise erratic performance.

Run No. 7—Oil B. At the end of this run the top cylinder injection valve was removed and found in first class condition, perfectly clean, with no gum, oil or scores of any kind on it. Clean combustion took place through the entire run.

Run No. 8—Oil C. The centrifuge was run only to fill engine run tank. This oil has high viscosity when cold but has a higher gravity—about 19 deg. B.—at centrifuging temperature, 190—200 deg. F. This oil contained no water but much more dirt than either oil A or B.

Run No. 9—Oil C. There was considerable difficulty in getting started, as the pump and all lines were filled with viscous oil. After getting them warmed up, however, no further difficulty was experienced.

All of the above-mentioned oils contained grit and sand, the worst one in this regard being Oil C, last run. Oil B was the only one that contained water and this was easily separated, at temperatures of 160 deg. F. and over. No difficulty of any kind was experienced either in cleaning these Diesel fuels with the Sharples Presurtite Super Centrifuge or in operating the engine on the centrifuged fuel.

Tests Show Need for Clean Oil

Need of an effective method for cleaning Diesel fuel oils is clearly indicated in the amount of impurities that were removed from the various oils in the course of the above tests. Perusal of the attached table of operating conditions shows that from 1.6 to 6.0 oz. of solid material were removed from each 100 gal. of oil by the Super Centrifuge. The variation is due to the different characters of the oils centrifuged. In any one oil, the amount removed runs fairly constant.

Analyses of samples of the removed material showed that it is composed roughly of 20 per cent water, 30 per cent oil, 30 per cent non-combustible material and 20 per cent asphaltic material. The most striking exhibit was obtained by washing a portion of the bowl solids in gasoline to remove oil. A grey residue remained that was gritty to the touch and in which coarse grains of sand and tank scale were apparent to the eye. Under the microscope, low power magnification clearly revealed sharp-cornered irregular crystalline sand, dirt and scale and carbon particles.

If a commercial engine of this type is made up of four cylinders similar to the one on which tests were run, it will consume about 170—200 gal. of fuel per hour instead of the 45—50 gal. burned per hour by the one cylinder engine in this test. With the 170—200 gal. of oil will go from 3 to 12 oz. of material that the centrifuge will remove. If not removed, approximately 1 to 4 oz. of non-combustible coarse sand, dirt, and scale will be introduced into the engine cylinders per hour.

In continuous operation this amounts to 1.5 to 6 lb. of abrasive materials per 24 hr. that enter the engine and contribute to liner and piston wear. The centrifuge removes this dirt and to that extent contributes to better operation and engine life.

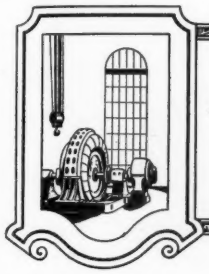
In addition, the centrifuge removes water from the fuel. In the tests on Oil B, this water was clearly in pockets in the oil, in which condition it was likely to cause misfiring and erratic operation.

TEST OF CENTRIFUGE TREATING OIL FOR DOUBLE-ACTING DIESEL ENGINE

Centrifuge Operation					Gallons of Oil		Impurities Removed from Oil					Engine Operation on Heavy Fuel				Oil Characteristics		
Date 1925	Run No.	Start	Stop	Hours Run	Total Run	Run Per Hr.	Average Oil Temp. Deg. F.	Gallons of Water Per 100 Gal. of Oil: Total	Per 100 Gal. of Oil	Ounces of Dirt: Total	Per 100 Gal. of Oil	Total Hours	Total Gal. Burned	Gal. Burned Per Hr.	R.P.M. Engine	Name	Gravity at 60 Deg. F.	Remarks
1/8	1	1:18	2:55	1:30	76.6	51	158	None	--	Combined with #2 Run	--	1:40	75	45	90	A	16 Deg. Be.	Engine oil consumption high. Air in oil caused misfiring
1/9	2	2:20	4:20	2:00	118.0	59	159	None	--	8.0 oz.	4.14 oz.					A	16 Deg. Be.	
1/12	3	9:45	3:25	5:40	263.4	46.5	161	None	--	12.0 oz.	4.6 oz.	5:40	241.1	42.55	120	A	16 Deg. Be.	
1/13	4	10:45	5:00	6:45	276.3	44.5	199.5	None	--	14.0 oz.	5.03 oz.	8:50	412.1	46.6	125	A	16 Deg. Be.	
1/14	5	10:45 3:25	2:00 3:55	2:45	142	51.6	182.5	Trace	--	4.0 oz.	2.8 oz.	1:30	57	38.0	120	B	11.8 Deg. Be	
1/15	6	10:20 3:20	2:40 4:00	5:00	308.1	61.6	167.5	3.5	1.2	7.0 oz.	2.2 oz.	6:00	283	47.0	--	B	11.8 Deg. Be	
1/16	7	9:40 10:00	9:50 12:10	2:20	94.5	43.0	165	2.5	2.6	1.5 oz.	1.6 oz.	4:30	236	52.4	90-125	B	11.8 Deg. Be	Vibration Tests and Indicator Cards Taken
1/17	8	9:30	11:45	2:15	99.4	44.2	194	--	--	5.0 oz.	5.0 oz.	--	--	--	--	C	19.0 Deg. Be	
1/19	9	9:40	2:20	4:40	273.0	58.5	202	--	--	17.0 oz.	6.0 oz.	7:10	372.5	52.5	--	C	19.0 Deg. Be	

Use of air mail for letters of which quick delivery is desired is increasing and it has become important that they be so designated that they will be readily separated from ordinary mail. Two designs are suggested: The first a red, white and blue band, not over ¾ in. wide, printed horizontally across the envelope not less than 1⅛ in. below the top, each color stripe to be not over ¼ in. wide. The second is two horizontal blue lines, approximately ¼ in. apart and not less than 1⅛ in. below the top of the envelope with "Via Air Mail" printed between them. If desired, similar blue lines may be put on vertical, not less than 3½ in. from the right hand end of the envelope.

The fellow who quits at the first reverse never gets anywhere.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Unusual Phases of Power House Lighting

PART II—MODERN METHODS OF LIGHTING THE TURBINE AND BOILER ROOM. ILLUMINATION OF GAGES. OUTDOOR SUBSTATION.* BY A. F. LOEWE†

IN THE UP-TO-DATE power generating station, to the uninitiated, there appears to be an unbelievable scarcity of operators upon whom, in great measure, depends the business life and security of the community. This is possible through the great strides that have been taken in late years in co-ordination of efforts, and equipping these stations with automatic and efficient labor-saving devices.

It is self-evident that these few men must effectively cover considerable area and many details. To do this, there should be ever present man's great gift, good illumination.

Characteristics of proper illumination will not vary from those required in other industrial fields; i. e., there must be sufficient intensity to perform the needed duties with celerity and safety, a lack of shadows, reducing industrial hazards as stumbling or coming in contact with moving machinery and charged apparatus, and a minimization of glare, both direct from unprotected light sources and reflected glare from shiny surfaces, such as polished metals, glass dial covers and glossy wall paints, or glazed bricks.

Means of obtaining these characteristics are many, and care should be exercised in the choice of proper equipment, both for generating the light and its redirection, as well as the spacing and hanging of the equipment, in order to get proper distribution of light.

Walls upon which light falls are a great factor in the resultant illumination to be obtained from any given installation and thought should be given to the choice of building material surfaces, or paints, for their reflection properties, permanency of color, stability and psychological, as well as physiological effects.

Sulphur fumes about the power house have a tendency to darken some paints more than others, depending upon the basic ingredients. A pure white, of course, has the greatest reflection coefficient, but in the lower expanses of the large wall areas a warmer tint is to be desired for the restful effect on the eye, whereas the dark dado is of advantage from the appearance standpoint, finger marks and smudges not showing so plainly.

A flat or mat finish is desirable on the ceiling and high walls, thus reducing the specular reflection and diffusing the incident light rays well, whereas the dado may be of a glossy finish which is easier to keep clean and free from finger marks.,

Figure 1 clearly shows the characteristics of up-to-date turbine rooms, both from the power equipment and illumination standpoint. The light colored walls and uniform spacing of high wattage and efficient intensive lighting

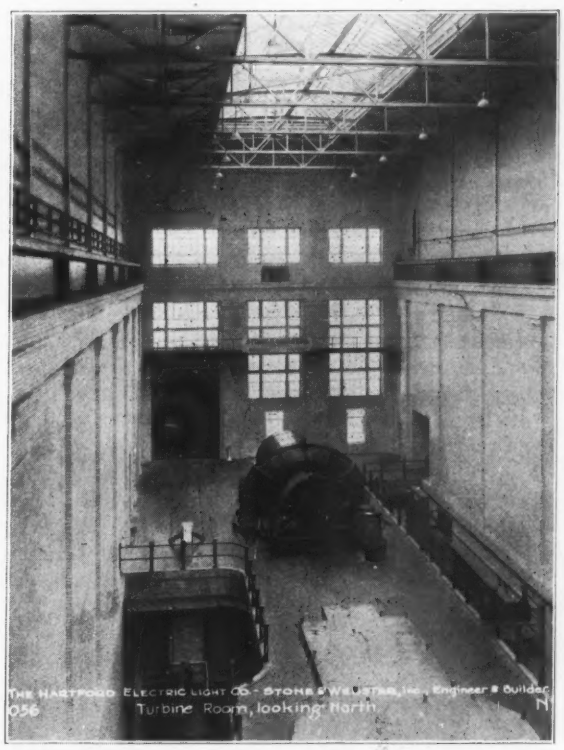


FIG. 1. MODERN TURBINE ROOM, COMBINING EFFICIENT PRISMATIC GLASS REFLECTORS WITH GOOD LIGHT DIFFUSING WALLS

units provide an adequate and pleasant illumination for ease of operation and safety. It will be noticed that local lighting is not required on the operating dial board.

Equipment for emergency lighting has become almost standardized and time will not be taken on this phase of the lighting system, except to caution that special care be taken to give safe illumination to passageways leading to gage and operating stations.

In the turbine or generating room, it is usual to find high ceilings ranging from 30 to 70 ft. with trusswork exposed, and also rails and beams accommodating traveling cranes. These conditions preclude the economical use

*Part I appeared in the Sept. 1 issue.
†Lighting Service Dept., Edison Lamp Works, Harrison, N. J.

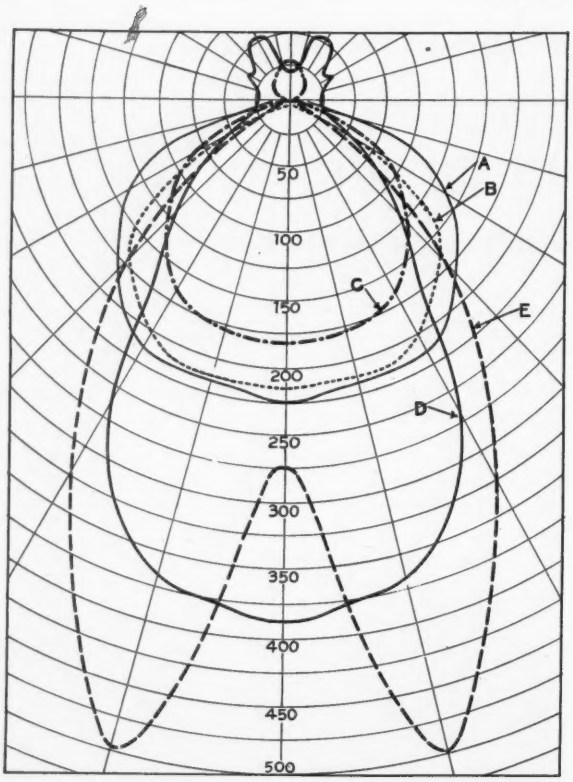


FIG. 2. CANDLE POWER DISTRIBUTION OF: (A) R. L. M. STANDARD DOME, (B) DEEP BOWL STEEL, (C) GLASSSTEEL DIFFUSER, (D) PRISMATIC GLASS REFLECTOR, (E) MIRRORED GLASS PROJECTOR. UNLIKE STEAM INDICATOR DIAGRAMS THE ENCLOSED AREA IS NOT A MEASURE OF THE TOTAL LIGHT OUTPUT, BUT THE VARIOUS COORDINATES ARE INDICATIONS OF CANDLE POWER VALUES AT DIFFERENT ANGLES

of any but direct lighting units, which may be of three types, intensive or extensive suspension, or angle type reflectors, or combinations of all.

In Fig. 2 one can readily compare the directional characteristics of the various types of reflectors which are used in general turbine room practice.

A standard type of extensive unit is the R.L.M. Standard dome (curve A, Fig. 2) which may be used to advantage with clear lamps, with hanging heights varying from 20 to 40 ft. Below 20 ft. bowl enameled lamps should be used in order to shade the bright filament. This type has a wide spread of light which overlaps from one unit to the other when proper spacing is employed, thus decreasing shadows cast by various pieces of equipment.

FIG. 3. GLASSTEEL DIFFUSER WHICH COMBINES THE CHARACTERS OF EFFICIENCY OF LIGHT OUTPUT AND MINIMIZATION OF GLARE

The units of this type in the rows near the walls, which are either painted with proper diffusing reflecting paint or inherently have a high reflection coefficient, will have a tendency to illuminate the upper regions of the walls and give a more cheerful appearance to the room than will the regular metal intensive type.

When contemplating the use of intensive type reflectors for very high ceilings, consideration should be given, first,

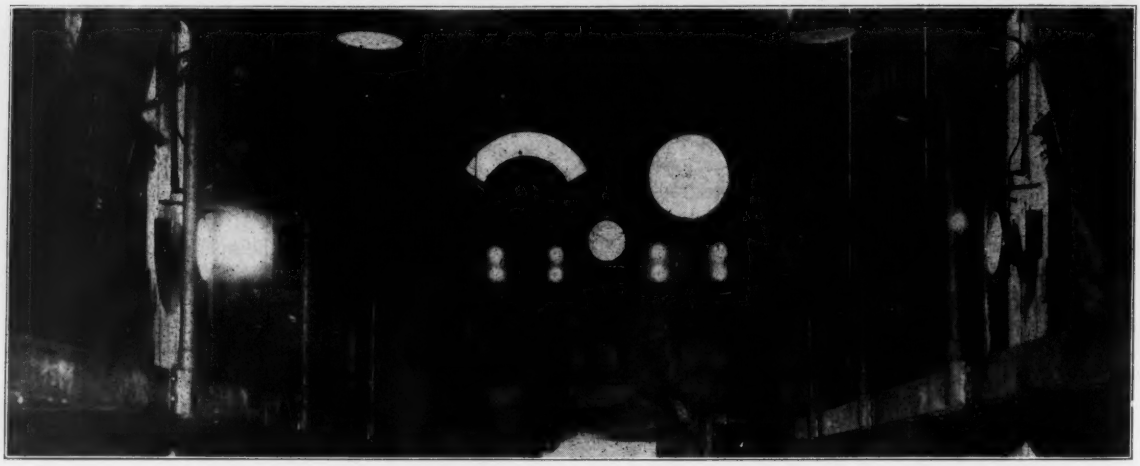


FIG. 5. COMPARISON OF GOOD AND BAD PRACTICE IN LOCAL ILLUMINATION OF DIALS

FIG. 4. PRISMATIC GLASS INDUSTRIAL REFLECTORS SO DESIGNED AS TO GIVE AN EFFICIENT DOWNWARD LIGHT AND A PLEASING UPWARD LIGHT

to illumination of the working area and second, to that of the roof or ceiling. The metal intensive (curve B, Fig. 2) and also the industrial projector type (curve E, Fig. 2) in general, have a light cutoff approximately 30 deg. below the horizontal for the former and 40 deg. for the latter where that of the extensive type is approximately 15 to 17 deg. Due to the greater degree of cutoff, some of the light is pocketed, and a loss is encountered in the intensive that is not found in the extensive type. The former, of the deep bowl metal enameled type has approximately the same candlepower output in the vertical angle as has the latter, and the real advantage in their favor is found in the additional shielding of the filament. For excessively high ceilings, there is no choice but to use the industrial projector, which has the greatest angle of cutoff and highest candlepower in the vertical angles.

In all metal types discussed there have been no provisions for light above the horizontal or that which illuminates the ceiling. There is, however, a type in both extensive and intensive reflectors which takes care of this matter. The former is the Glassteel diffuser, Fig. 3 (curve C, Fig. 2) which consists of an enameled metal reflector with holes in the top and underneath the reflector is fastened a diffusing globe of opalescent glass. The latter, or intensive type, consists of a prismatic glass reflector, Fig. 4 (curve D, Fig. 2), with an open top, which allows approximately 20 per cent of the light to escape to the ceiling. In the Glassteel diffuser this amounts to 7 per cent.

Lighting in the Boiler Room

Without a doubt, the lighting equipment in the boiler house proper undergoes the greatest and quickest depreciation of light output. In this area, good illumination is one of the great factors in bolstering up the worker's pride in the maintenance of his surroundings. Here, especially, provisions should be made for regular cleaning of the

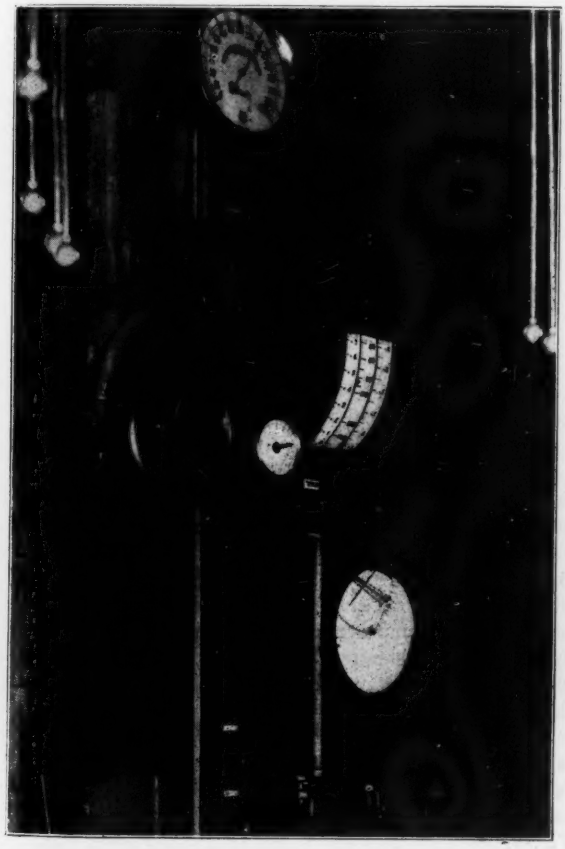


FIG. 6. IN THIS FIGURE WILL BE NOTED THE CLEARNESS OF DIAL FACES, PROCURED WITH SUFFICIENT GENERAL ILLUMINATION

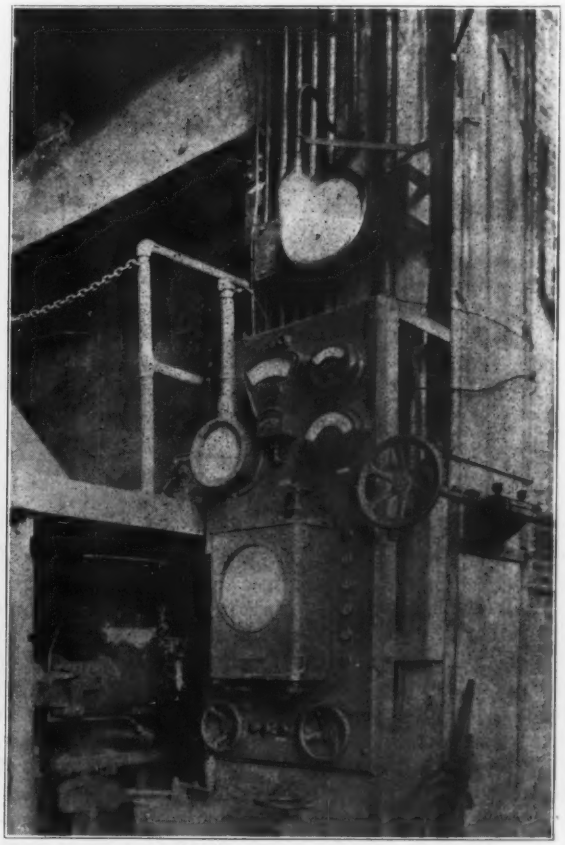


FIG. 7. THE LACK OF GOOD ILLUMINATION AND THE CONDITION OF GLARE FROM THE BARE LAMP IS CLEARLY INDICATED IN THIS PICTURE

various lighting units. There are several good cutout hangers on the market today which enable the lighting units to be lowered with safety from their great hanging height.

Where installations are made of prismatic glass reflectors in the firing aisles, it is considered good practice to cover these with spun aluminum shells. This lessens the rate of depreciation considerably. In the firing aisle it is often necessary to place the lighting units above the coal larry. This necessitates a unit which projects the maximum light in a vertical angle. Great losses in efficiency in the total output of the generating station may occur in the slack operation of the boiler house. To overcome this there must be an accuracy and uniformity of operations which in turn depend upon the reading of gages, columns and various other indicating and recording devices. Without good illumination this accuracy of operations would be

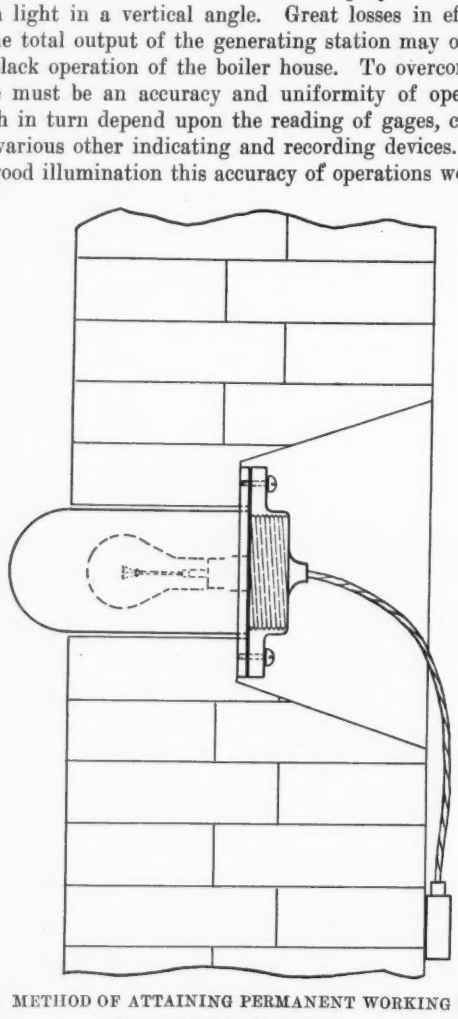


FIG. 8. METHOD OF ATTAINING PERMANENT WORKING LIGHT IN ASH HANDLING PIT

seriously hampered, so we find the need of various types of local lighting units.

In Fig. 5 a ready comparison can be made of poor practice in gage lighting and a more modern method. The former type, using bare lamps, introduces a factor of glare and specular reflections which are detrimental to quick and accurate reading. In the latter type shown in the two central gages illumination is procured indirectly, which results in clear-cut dial figures and elimination of glare.

Where high intensity general illumination is used, supplementary gage lighting is not required in many cases.

Figure 6 shows the beneficial results of such illumination as compared with inadequate supplementary gage lighting with bare lamps as shown in Fig. 7.

Conditions met with are so varied in nature, that it would be almost impossible to prescribe, in general, equipment to produce the desired results. There are, however, certain characteristic qualities which should be obtained by any equipment for such purposes. First, a lamp illuminating the dial or plate should be in such a position that the filament, as well as the specular reflection resulting from it, is hidden from the observer's view.

Intensity of light upon the face of the instrument should be of such a level that there will be no difficulty in picking out the dial from the rest of the surroundings. The illumination should be received from more than one light source, and be of a diffused character, in order to minimize shadow which, in itself, might introduce a similar error as might result from parallax.

In the ash hoist pit light is needed at times in order to clean out and break up jams and it is desirable to have this illumination easily accessible when needed. Of course, we may have extension cords; but this is not always satisfactory, due to wear and tear on equipment and inconvenience of use.

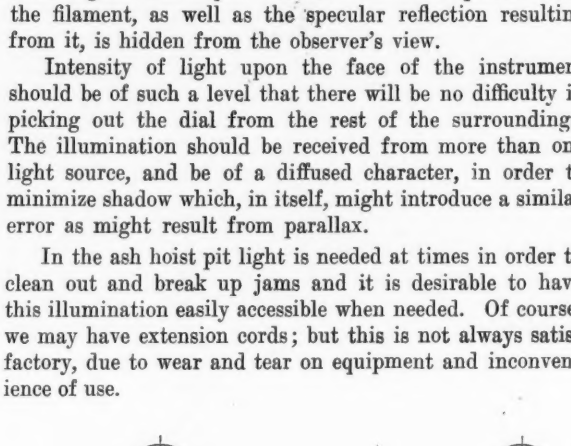


FIG. 9. WATER COLUMN INDICATOR SHOWING FLEXIBILITY OF EQUIPMENT FOR VARIOUS SIZES OF COLUMNS AND METHOD BY WHICH TOTAL REFLECTION IS OBTAINED AT MENISCUS OF WATER COLUMN

One exceedingly good method of overcoming these difficulties is to install a lamp in the vapor proof globe and housing in the brick work of the pit, as shown in Fig. 8.

Flange A is permanently set in the brick and Flange B, which is on the vapor-proof globe, carries three screws which engage in thread in Flange A. When cleaning or replacement of lamp is required, this is easily accomplished by removal of fastening screws which in turn release the globe and the entire equipment may then be withdrawn through the brickwork.

One of the most difficult gages to illuminate and to read is the water column; however, a unique, efficient, and satisfactory means of illumination has been developed. This is known as a water column illuminator, and is shown in Fig. 9.

Light rays of the two lamps are so directed that the beams are totally reflected from the meniscus at the water level, providing a rapid and sure indication of the level.

In the safe-guarding of human life and the reduction of human efforts, the manual operation of large switches has been almost entirely superseded by the use of automatic and safe methods. One of the latest safe developments is the application of master-lock systems, which prevent the opening of oil switch compartments, when the switch is still engaged. With the application of these mechanical safe devices, it is high time that cognizance be given to the necessity of lighting for safety, especially in these long, narrow lanes of oil switch compartments. Reflectors giving a symmetrical distribution of light, obviously, will not be satisfactory in such an area, unless installed in uneconomical and unsightly numbers. To overcome this difficulty, a prismatic glass reflector with an asymmetrical distribution of light has been developed, primarily, for use in corridors but is well adapted indeed to light, not only the length of the oil switch alley but also the inside of the compartment when the safety door has been removed. This is particularly true when the inside of the compartment has been painted a flat white. The photometric curve showing the distribution of light from this unit is shown in Fig. 10.

It would be poor practice in and about a power station to have any area in darkness at any time, especially one of such importance as the oil switch compartments. A unit with an asymmetrical distribution of light is, therefore, well adapted to the burning of non-adjacent units for ordinary safe passageway illumination.

The network of high tension lines which practically covers the entire continent has necessitated the erection of large substations in various localities, ranging from the congested downtown district of the large city to the quiet open spaces of our rural communities. There is just as great a variation in the many construction details of the substation, ranging from the totally enclosed automatic substation, to the large outdoor substation consisting of lofty overhead iron work construction with a maze of high tension wires and the ground space covered with various transformers and other equipment. It is with this latter type that I shall deal at present.

In general, when we speak of the working plane in illuminating engineering we consider a height of the average desk or bench; however, the working plane of the outdoor station is found from 10 to 20 ft. above ground level, is vertical rather than horizontal and the operator must view the knife, disconnecting switches, etc., against variations of sky from the bright summer day to the stormy and snow-laden atmosphere of winter. Little does the average consumer of electrical energy realize the hardship encountered by the substation operator in times of trouble. It has been only in the last few years that any real attempt has been made to give the operator the aid of good illumination in his outdoor work. Clearly can the writer recall running into the downpour of the summer storms with a disconnecting switch-pole in one hand and flashlight in the other, the purpose of the whole operation being to engage the knob of the pole in the small hole of disconnecting switch, in order to secure safety for the linemen out on trouble. This, of course, sounds easy; but with the wind blowing the pole, the rain flooding the eyes and being temporarily blinded by the lightning, it was indeed a most difficult operation to perform, aided with the feeble rays of a flashlight. How different would the operation have been had there been supplied even a low intensity of general illumination! In order to illuminate this high working plane as encountered in substation construction, many difficulties are encountered. First, in the placement of units, due to the overhead lines and iron structure; second, the possibility of looking directly into some adjacent lighting unit; third, the great possibilities of shadows cast, not alone by the framework but the high equipment, such as vertical transformers.

Lighting of outdoor substations is a comparatively new field. The small number of stations illuminated at present and the wide variation of conditions, precludes the laying down of general rules. From the data obtainable, however, the present indications are that some forms of floodlighting projectors, street lighting units and weather-proof angle type reflectors are adaptable for the conditions met with. The operating forces of the stations, being familiar with local conditions and the illumination characteristics of various types of lighting equipment, are in a position to provide safe night operating conditions with good illumination.

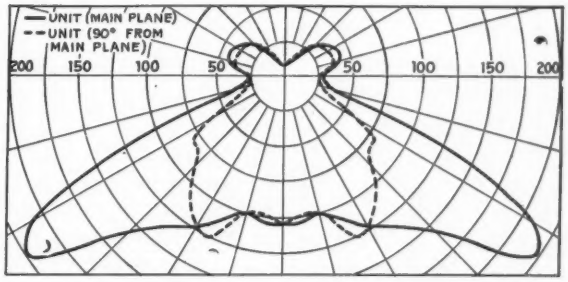


FIG. 10. CANDLE POWER DISTRIBUTION CURVE OF ASYMMETRICAL PRISMATIC GLASS REFLECTOR

Yet another use of floodlighting is the illumination of the generating station itself. Since these are generally situated on the railroad or waterways, this is indeed a profitable means of advertising, and can be used to especial advantage when an attempt is made to interest the consumer in becoming a stockholder.

Proverbially the shoemaker's child goes barefoot; but this is the age of progress and of merchandising by display and suggestion, so since good illumination may be procured economically and the benefits to be derived are so great, it behooves the central stations to become leaders in the art from a merchandising standpoint, if from no other.

Use of Electrically Driven Auxiliaries Increases

INFORMATION contained in the article bearing the above title that appeared in the March 15 issue was obtained from the report on auxiliaries for 1924-1925, recently issued by the Electrical Apparatus Committee of the N. E. L. A., as a result of investigations conducted by a special subcommittee under the auspices of the Generating Stations Subcommittee. The membership of this special subcommittee was as follows: Chairman, N. L. Pollard; J. W. Dodge, R. A. Hentz, H. W. Smith, R. H. Tapscott and A. H. Kehoe. Mention of the fact that the Electrical Apparatus Committee was responsible for the report was inadvertently omitted from the article. In securing some of the data, this committee naturally co-operated with the Heat Balance Subcommittee of the Prime Movers Committee.

Power Plant Wiring

IN THE March 15 issue, in the article Modern Practice in Power Plant Wiring, a table was presented which gave current carrying capacities of insulated conductors for approximately 30 deg. C. temperature rise. Included in this tabulation designated as Table II, were the current carrying capacities for cables in different sizes of conduit, but due to the omission of certain heavy black lines, the table as published was not complete. The purpose of the heavy lines was to indicate which cables were to be used in connection with certain sizes of conduit.

To avoid any inaccuracies that might result from the use of this table, we are republishing it, with the heavy black lines drawn in. Thus, it will be seen that under conduit wiring, single conductors, 750 v., 360 and 175 amp. maximum current, ½ in. conduit may be used with No. 10, 8, and 6 B. & S. gage conductors, when carrying currents as indicated.

Similarly, ¾ in. conduit may be used for 750-v. cable, No. 4 and 2 B. & S. gage when carrying 70 and 110 amp. respectively for rubber covered, 110 and 130 amp. respectively for varnished cambric, and with No. 6, 3500-v. conductor when carrying 50 amp.

TABLE SHOWING CURRENT CARRYING CAPACITIES OF INSULATED CONDUCTORS FOR APPROXIMATELY 30 DEG. C. TEMPERATURE RISE

Size of Conductor	Open Wiring							Conduit Wiring																	N.E.C. RATING		
	Single Conductors					2 or 3 Cond. Cable		Size	Single Conductors											Size	Size	2 or 3 Conductor Cables			Size	Table A	Table B	Table C
Max.Voltage	750	750	3500	3500	15000	750	15000	Of	750	750	750	750	750	3500	3500	15000	15000	Of	Of	Of	750	15000	15000	Of			
Max.Current	1300	1500	175	1300	1300	550	550	Conduit	360	1075	175	675	1075	675	1075	675	1075	Conduit	Conduit	Conduit	550	175	360	Conduit			
Insulation	Rub.	V.C.	V.C.	V.C.	V.C.	Rub.	V.C.		Rub.	Rub.	V.C.	V.C.	V.C.	V.C.	V.C.	V.C.	V.C.				Rub.	V.C.	V.C.		Rub.	V.C.	Other
12 B & S																									25	30	30
10 B & S	15	15				8			15		15										8				35	40	50
8	35	35				25			35		35										25				50	60	70
6	50	70	70		50	35	50	1/2"	50		70			50		50					35	50			70	85	90
4	70	110	110		70	50	70		70		110			70		70		1-1/2	1-1/4		50	70			90	110	125
2	110	130	130		110	70	110	3/4"	110		130			110		110			1-1/2		70	110		3	125	150	200
0	130	175	175		130	110	130		130		175			130		130					110	130			150	180	225
00	175	225		175	175	130	175	1"	175			175		175		175			2"		130	175		3-1/2	225	270	325
0000	225	290		225	225	175	225		225			225		225		225		2"	2-1/2		175		175		275	330	400
300000	290	360		290	290	225	290		290			290		290		290					225		225	4	325	390	500
400000	360	450		360	360	290	360	1-1/4"	360			360		360		360					290		290		400	480	600
500000	450	550		450	450	360	450	1-1/2"		360		450		450		450		2-1/2	3		360		360	4-1/2	450	540	690
600000	550	675		550	550	450	550	2"		450		550		550		550			3-1/2		450						
750000	675	775		675	675	550				550		675		675		675		3	4"		550						
1000000	775	900		775	775			2-1/2"		675			675		675		675								650	780	1000
1250000	900	1075		900	900			3"		775			775		775		775	3-1/2									
1500000	1075	1300		1075	1075					900			900		900		900	4							850	1020	1360
2000000	1300	1500		1300	1300			3-1/2"		1075			1075		1075		1075	4-1/2							1050	1260	1670

Current Carrying Capacities of Insulated Conductors for approximately 30° C Temp. Rise
Abbreviations. Rub. = Rubber Covered, V.C. = Varnished Cambric.

Practical Transformer Calculations

A SIMPLE METHOD OF DETERMINING CERTAIN TRANSFORMER CHARACTERISTICS. BY FRED C. DEWEESE

IT IS OFTEN desirable to know the value of the iron and copper loss of a transformer, separately, and also the value of the resistance volts and the reactance volts, separately, when only the efficiency and per cent impedance are given. For this reason the author is illustrating a simple and easily applied method for determining these values.

For example: Suppose we have a 1000-kv.a., 13,200-v., 60-cycle, three-phase transformer, or, three 333-kv.a. transformers with only the following data given.

Full load efficiency 98.2 per cent; half load efficiency 97.8 per cent; impedance 4.7 per cent, and we wish to know the value of the iron loss, which is constant at all loads, copper loss at any load, the copper loss varies approximately as the square of the load, the resistance volts, the reactance volts and the short circuit current which will flow through the transformer windings with full sustained voltage.

If the efficiency is 98.2 per cent, the total combined losses, at full load equals

$$100 - .982 = .018 \text{ or } 1.8 \text{ per cent}$$

At half load the losses are $100 - .978 = .022$ or 2.2 per cent

The input at full load equals $1000 \times 1.018 = 1018$ kw. or 18,000 w. loss

The input at half load equals $500 \times 1.022 = 511$ kw. or 11,000 w. loss

The following simple and easily applied algebraic equations may be used for determining the unknown values.

Let x equal the iron loss at all loads

And y equal the copper loss at full load.

Then: $$x + y = 18{,}000 \qquad (1)$$

and as the copper losses are proportional to the square of the load the copper loss at half load is equal to

$$x + \frac{y}{4} = 11{,}000 \qquad (2)$$

Clearing (2) of fractions $4x + y = 44{,}000$ Eliminating y by subtracting (1) from (2) we have

$$x + y = 18{,}000$$

$$3x = 26{,}000$$

$x = 8667$ w. iron loss.

and y equals $18{,}000 - 8667 = 9333$ w. copper loss, at full load.

Iron loss in per cent of full load equals

$$\frac{8.67}{1000} \times 100 = 0.87 \text{ per cent.}$$

Copper loss equals

$$\frac{9.33}{1000} \times 100 = 0.93 \text{ per cent}$$

As the percentages of resistance and reactance are expressed in terms of voltage to neutral, it will be necessary to reduce the voltage to neutral, which is

$$\frac{13{,}200}{1.73} = 7600 \text{ v.}$$

The voltage drop through the transformer windings, due to the ohmic resistance, is equal to

$$.0093 \times 7600 = 71 \text{ volts to neutral.}$$

Since the impedance (4.7 per cent) and the resistance are known, the reactance in per cent is equal to

$\sqrt{(4.7)^2 - (.93)^2} = 4.61$ per cent. The reactance volts is therefore, equal to

$.0461 \times 7600 = 350$ v. to neutral.

The total impedance volts are

$\sqrt{(71)^2 + (350)^2} = 357$ v. to neutral.

Or as a check on the work

$0.047 \times 7600 = 357$ v. to neutral.

The full load current is equal to

$$\frac{1{,}000{,}000}{7600 \times 3} = 44 \text{ amp.}$$

As the short circuit current is approximately equal to 100 divided by the per cent reactance, we have

$$\frac{100}{4.61} = 21.7 \text{ times normal current.}$$

The short circuit current will be $44 \times 21.7 = 955$ amp., with full sustained voltage.

The resistance in ohms, as referred to the primary, or the high voltage, is equal to

$R = 71/44 = 1.6$ ohms. Resistance.

$X = 350/44 = 7.96$ ohms. Reactance.

$Z = \sqrt{(1.6)^2 + (7.96)^2} = 8.14$ ohms. Impedance.

Regulation

Per cent regulation at unity power factor equals

$$\text{Per cent IR} + \frac{(\text{Per cent IX})^2}{200}$$

$$= .93 + \frac{(4.61)^2}{200} = 1.036 \text{ per cent}$$

Per cent regulation lagging power factor equals

Per cent IR cos Θ + Per cent IX sin Θ

at 80 per cent P. F. lagging per cent regulation =

$0.93 \times 0.8 + 4.61 \times 0.6 = 3.51$ per cent

Per cent regulation at leading power factor load equals

Per cent IR cos Θ — Per cent IX sin Θ

at 90 per cent leading power factor

$0.93 \times 0.9 - 4.61 \times 0.435 = -1.168$ per cent

In this case the regulation is negative, that is, the secondary voltage is higher at full load than at no load.

Tabulating the values as now known we have

Total full load loss, kw	18	
Iron loss, kw	8.67	
Copper loss full load, kw	9.33	
Resistance volts	71	0.93 per cent
Reactance volts	350	4.61 per cent
Impedance volts	357	4.70 per cent
Current in amperes	44	
Short circuit current, times normal	21.7	
Short circuit current, amperes	955	
Regulation at unity P. F. per cent	1.036	
Regulation at 80 per cent lagging P. F. per cent	3.51	
Regulation at 90 per cent leading P. F. per cent	—1.168	

Centralized Building Heating Service

Central Plant Idea Adapted to Heating of Group of Small Buildings. By Louis A. Foster

RECENT trend of real estate operations, both in cities and smaller communities, leans toward a plan of grouping ten to twelve attractive residences fronting on an open court or plaza, which provides comparative privacy and security from ever-increasing street traffic. Homes so situated enjoy every convenience in the form of utility service, such as gas, electric light, water and telephone. In recent years, even refrigerating machines for each house are common, but there remains the necessity of the delivery of coal for heating to each home and the removal of ashes regularly. Therefore, the owner is still confronted with the "bugaboo" of furnace attendance and the resulting nuisance of dirt and smoke, a situation which can be overcome by the centralization of the heating equipment into one small, compact, low-pressure heating plant, distributing steam underground to each residence.

In many large cities, the business districts are so served, either by low or high-pressure underground steam systems, and often such service extends to or is located in the residential districts. Today some 600 heating companies are operating, giving, with few exceptions, excellent service at reasonable cost when all factors are properly considered. These systems represent millions of dollars of investment and are managed by skilled operators. The writer is fully aware of the factors governing such installations from both the engineering and economic standpoints. Heavy investment is required because of the concentrated areas served but, in the case cited, the investment covering the centralized plant is practically offset by that necessary for the installation of individual heating plants and, considering the operating expense, the balance is in favor of the centralized scheme. Therefore, the thought here is to show by illustration that Centralized Residence Heating Service is both practical and economically sound when applied to small grouped communities such as previously outlined.

A Grouped Building Installation

Last fall the writer designed and built an underground heating system which illustrates clearly the feasibility of adapting this medium of heating to a group of homes, for referring to the accompanying drawings, it is not hard to visualize this system as serving homes instead of garages, storerooms, etc. This group of ten buildings occupies about the same area that a dozen homes would cover, while the space occupied by the boiler plant is small in comparison.

The actual heating plant building is 33 by 16 ft. which is about the same size as a private garage. This small building houses the boiler, also provides ample storage space for coal for several days' run. The smoke stack base is built integral with the walls, being lined with fire brick. The stack is $\frac{3}{16}$-in. steel with special structural steel supports anchored to the roof, thus avoiding unsightly guy wires.

Supply and return mains of the vacuum system leave the plant underground from a pit 5 by 6 by 8 ft. in which is located a combination electric-driven vacuum pump and boiler feeder. Thus the condensation from the buildings

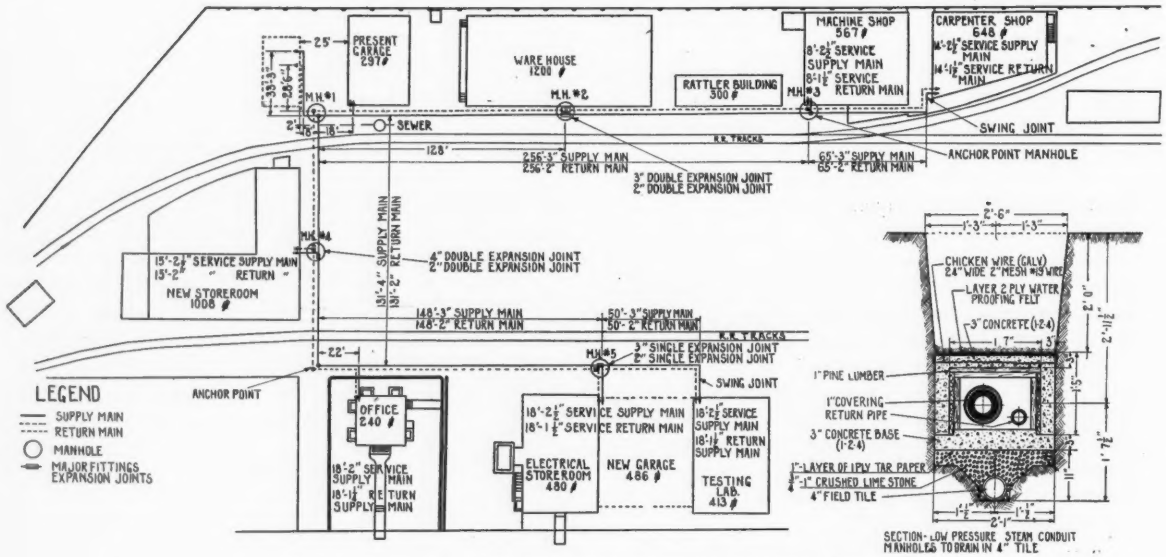


FIG. 1. LAYOUT OF TEN-BUILDING CENTRAL HEATING SYSTEM

is entirely recovered and is automatically returned to the boiler. This type of equipment is very reliable, requiring no maintenance other than weekly inspection and oiling, which is handled by the fireman.

Maximum pressure on this system during zero weather this past winter was 4 lb., with a vacuum of 6 in. carried on the return lines. The pipes are compactly incased in a concrete box envelope, well underdrained, steam lines being carefully covered with high-grade laminated sectional covering and waterproofed with felt.

Steam lines are standard weight Spellerized steel pipe while the returns are the same material but extra heavy weight. Welding was employed throughout so that there are no cast-iron fittings underground except expansion joints located in the manholes. Originally a few fittings were specified but, owing to delays in shipment, these were replaced with pipe bends welded into place. Standard brass-sleeved expansion joints were used on the steam lines but corrugated copper joints were found most feasible for the return lines under vacuum. Traps are located in the manholes and discharge directly into the return line at those points. The lines were tested at 60 lb. water pressure and found tight. Each building is fed by a service and return line with supply and return valves located just inside the walls.

Running the Plant

Operation of the plant and system is simple. One man is required per watch of 8 hr., his duties consisting of maintaining steam on the boiler and removing ashes. The boiler is smokeless when burning mine-run coal on down draft grates. Where hot water is desired, a small hot-water generator is connected between the steam and return mains in the buildings, with city water from a range boiler circulated through the heater.

It is hardly necessary to mention that the efficiency for such a plant is far greater than for 10 or 12 individual furnaces or boilers. It must be remembered, also, that one smoke stack replaces ten or twelve.

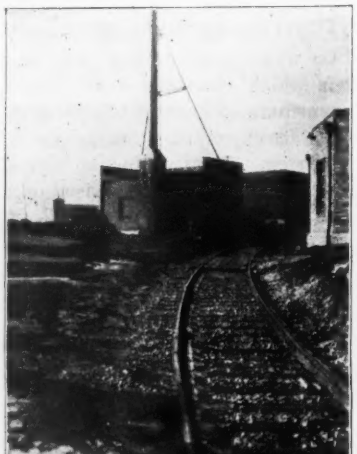


FIG. 2. THE HEATING PLANT IS AT ONE CORNER OF THE GROUP. STEEL STACK IS ANCHORED TO THE ROOF

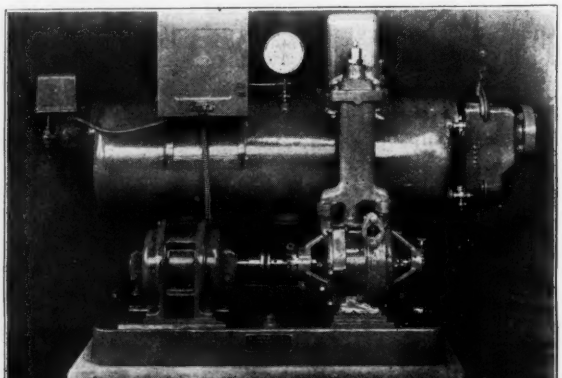


FIG. 4. CONDENSATE IS RECOVERED BY A COMBINED VACUUM PUMP AND BOILER FEEDER

In considering the relative cost of such a plant as compared to the cost of ten or twelve individual heating plants, it is necessary only to balance the cost of underground mains and small boiler plant and equipment against the cost of the individual house furnaces including the relative value of the space occupied. Cost of the interior piping and radiation would be approximately the same in either case.

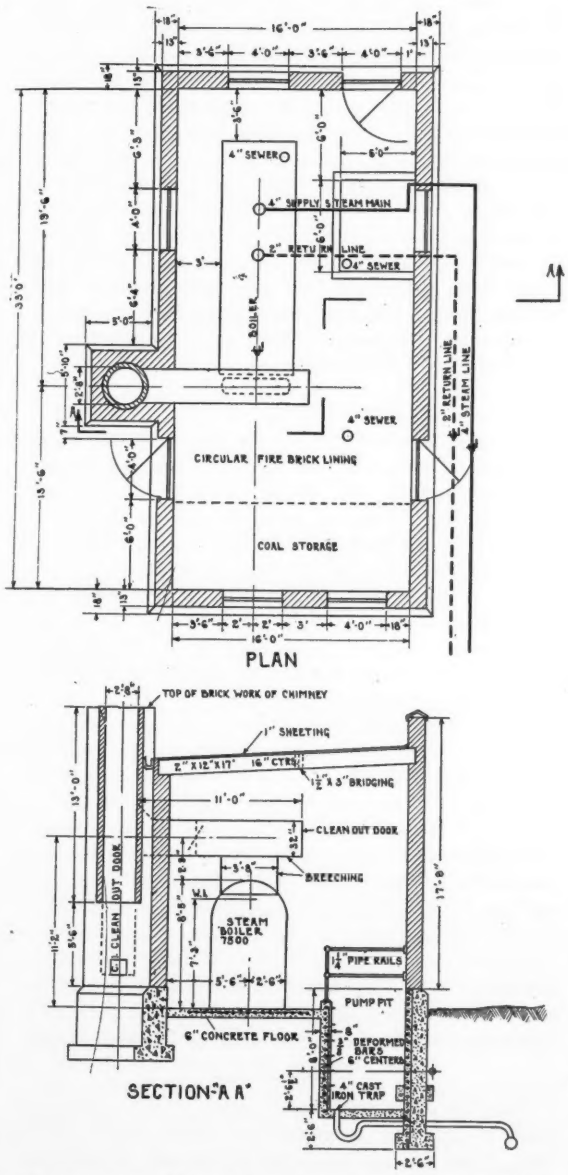


FIG. 3. PLANT IS 33 BY 16 FT. WITH ONE BOILER 7500 SQ. FT. H. S.

A system of this nature should be designed by an engineer thoroughly familiar with underground steam construction to insure a design embodying satisfactory service, economy and permanency. It is only necessary to use standard materials intelligently, to keep the construction costs well within justification of the project. The problem is merely to make a logical and thorough study of the situation, which can be done in relatively short time by a competent man.

Simple Changes Put Ice Plant on Paying Basis

REARRANGEMENT OF PIPING, USE OF EXHAUST STEAM AND PROPER AMMONIA CHARGE LEAD TO ECONOMY IN THIS SMALL PLANT. BY H. A. CRANFORD

SOMETIMES IT is possible to make changes in a plant that will result in great saving without spending a large amount of money. I have in mind a city water and light plant in a southern town that had a 10-T. absorption ice plant in connection with it. The ice plant, which had been bought second hand 2 yr. before, had proved a losing proposition and the owners were about to close it down, although there was no other ice plant in the town to offer any competition. Finally, when the ice department had lost so much money that something had to be done, one of the directors suggested that they call in a man who had been highly recommended to them and see what suggestions he had to offer before they decided definitely what disposition they would make of the ice business.

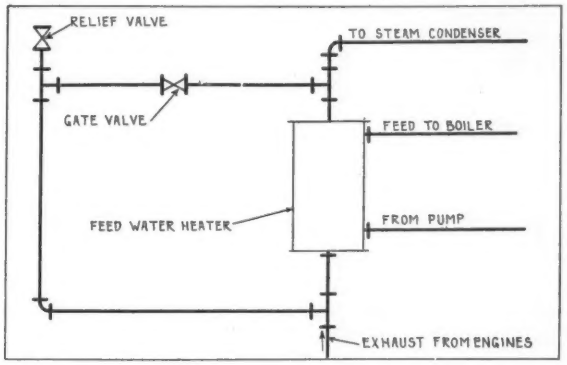


FIG. 1. POOR CONNECTIONS OF EXHAUST AND FEED-WATER HEATER WASTE STEAM

When the new man came, he had little trouble in locating the reason for the losses. He found the absorption system operating on live steam at boiler pressure and the exhaust going to waste; in fact the exhaust was not even properly connected to the boiler feed-water heater. It was connected as in Fig. 1.

Changes were made as shown in Fig. 2. The boiler feed-water connection was carried into the top of the heater and out of the bottom to the boiler, giving a counter flow effect. When the engineer suggested that the exhaust be carried to the generator before going to the steam condenser, the owners, after inquiring the cost of the change, decided not to spend more money until they could see something coming in from the ice department. Furthermore, somebody had told them that the ammonia generator was a live steam generator and would not work on low pressure steam anyway. The new man knew better; he knew that the biggest loss in the plant was caused by letting all the exhaust steam get away. He decided, however, to do the best he could to convince them, but thought he would let the matter drop for a few days until he could make some other changes that would convince them that he knew what he was talking about.

Testing the ammonia charge, he found that he had too much aqua ammonia but that it was much under strength. After thoroughly purging the system, he distilled off all

the anhydrous he could get, storing it in the receiver and condenser; then he took about 40 gal. of very weak aqua out of the generator. He next expanded the anhydrous ammonia through the coils into the absorber, allowing the absorber purge valve to remain open until all signs of foul gas disappeared. It happened that there was a cylinder of anhydrous ammonia in stock and he expanded this into the system also. After allowing the plant to run a few hours, so that the ammonia was thoroughly mixed, he found upon testing the weak liquor that it was within a degree of the desired strength and that the generator was working well on 15 lb. pressure, using live steam.

This delighted the owners and the engineer again brought up the matter of fittings to connect the exhaust steam to the generator. But someone had convinced the president of the company that it would be cheaper to run on 15 lb. of live steam than to run the power plant engines against any back pressure and they wouldn't buy the necessary fittings.

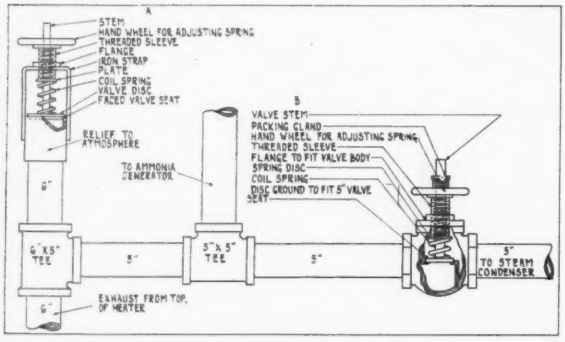


FIG. 2. CONNECTIONS ARRANGED THUS, WITH HOME-MADE VALVES A AND B, RESULTED IN LARGE SAVING

At this point, the new engineer got mad and made up his mind that he was going to convince his superiors that he was right. There was a good lathe and a drill press in the plant, an assortment of old tools, valves and fittings and a big junk pile. After looking things over, he proposed to the owners that if they would allow him to make the change without buying any new material, if there was not a big saving in fuel, he would not charge a penny for his services. If, on the other hand, he proved that his ideas were correct and that there was a saving of a ton or more of coal each 24 hr., they were to pay him $750 for his work, above what actual expenses he might incur, provided the expenses did not exceed $100. They readily agreed to this.

Valves Were Made From Odd Fittings

First, he built a relief valve as shown at A in Fig. 2. The coupling was faced off, iron straps fastened on as shown and threaded to fit the threaded sleeve, and a valve disc was fitted to the coupling. By use of the hand wheel fitted to the sleeve, the pressure on the coil spring could be regulated so that the steam would relieve at the desired pressure. This valve was set to open at 5 lb. higher pressure than was wanted at the generator. Next, the engineer made the valve shown at B, Fig. 2, using a 5-in. globe valve and some odd fittings as shown. This valve was adjusted to the pressure desired on the generator.

Again the system was thoroughly purged and enough anhydrous ammonia was added to bring it up to the required strength. The plant was put into operation and operated well on 8 lb. generator steam pressure. After connecting all units to the generator and condenser, it was found that there was now a great excess of distilled water. The condenser was elevated to carry the necessary amount to the ice plant forecooler by gravity, doing away with a troublesome distilled water pump. The rest of the distilled water was piped for gravity flow to the boiler feed-water tank and the boiler feed pump was lowered until water flowed to it by gravity. The cooling water from the condenser was also piped to the feed tank. The boilers had been giving a lot of trouble from scale, having to be scaled at least every two weeks because of the increase in temperature in the condenser as a result of piping all exhaust steam to it. The scale was practically all deposited on the flask condensers and the increased temperature of the cooling water going to the boiler feed-tank, in connection with the amount of distilled water going into it, made an ideal feed water. One boiler was actually run 17 weeks without opening it up and when inspected was found to be practically free from scale, with no signs of pitting. The boiler feed water going into the pump had a temperature originally of 140 deg. but after the changes were made, this was found to be 205 deg.

Plant Shows Profit After Changes

When a test was run on the plant, it showed a coal consumption of 2.1 T. per day less than the average for the season before. Of course the valves on the engines had to be reset, using an indicator to find the closest adjustment for the back pressure that was carried. From a statement from the owners that I have read, this plant jumped from a loss in 1923 of $3100 to a profit in 1924 of $3700 or a total difference of $6800 in the ice department alone. Some of this should probably be credited to the power department but in these small plants they do not use elaborate accounting methods.

In conclusion, let me say that it took the trouble man over three months to get his fee, not because the owners were not satisfied, but because they said they didn't have the money. I suspect, however, that the saving was so great that they were suspicious, and afraid that he had put something over on them that would not last. When they did finally pay his bill, they added $250 to the amount and asked him to select a competent man to handle their plant. A young man has been put in charge and is making other improvements that will result in still more economy. Many plants that today are losing good money could be put on a good paying basis by just such an intelligent application of common sense as I have described.

Insurance with "unauthorized" foreign companies is liable to yield only a lawsuit in a foreign court in case of loss. Some foreign insurance companies are admitted to do business in the United States and give the same protection as domestic companies. But others, as pointed out in a bulletin of the Insurance Department of the United States Chamber of Commerce, do not comply with American laws, yet secure business through brokers and by mail without supervision of the State, payment of taxes or receiving a license. Naturally, a company which will resort to such practices cannot be considered reliable and, before taking a policy with a foreign company, a policy holder should find out whether or not that company is authorized to do business here and has made itself accountable under our laws.

Eagle Paper Company Now Produces Own Power

STARTING WITH AN M.-G. SET AND TWO H. R. T. BOILERS THIS PLANT HAS BEEN DEVELOPED INTO A HIGHLY EFFICIENT GENERATING UNIT

ONE RECENT example of the utilization for power of the water and steam required by a manufacturing process has just been worked out and placed in service by the Eagle Paper Co., Joliet, Ill., with the assistance of V. D. Simons, industrial engineer of Chicago. A simple boiler plant and public utility electric supply had been in use since the inception of the mill in 1920. Electrically pumped deep well water was evaporated into steam of 85 lb. gage pressure and 2200-v., three-phase service had been stepped down to 440 v. and part of the energy converted into 250 v. for the variable speed paper machine drive. Other equipment was driven by induction motors.

The main generating unit is a 500-kw. at 80 per cent power factor, Allis-Chalmers, 3600-r.p.m., 3-phase, 440-v. turbo-generator, designed to operate with 300 lb., 200 deg. F. superheated steam and to exhaust against 15 lb. gage back pressure. Motor equipment of the mill was left undisturbed and the only additional connected load is imposed by six new Westinghouse direct-current motors in the boiler plant.

In case of an interruption to the main alternating current service, the output of the synchronous motor member of the auxiliary unit can be run as an alternator. A third machine designated as the "service generating unit" was

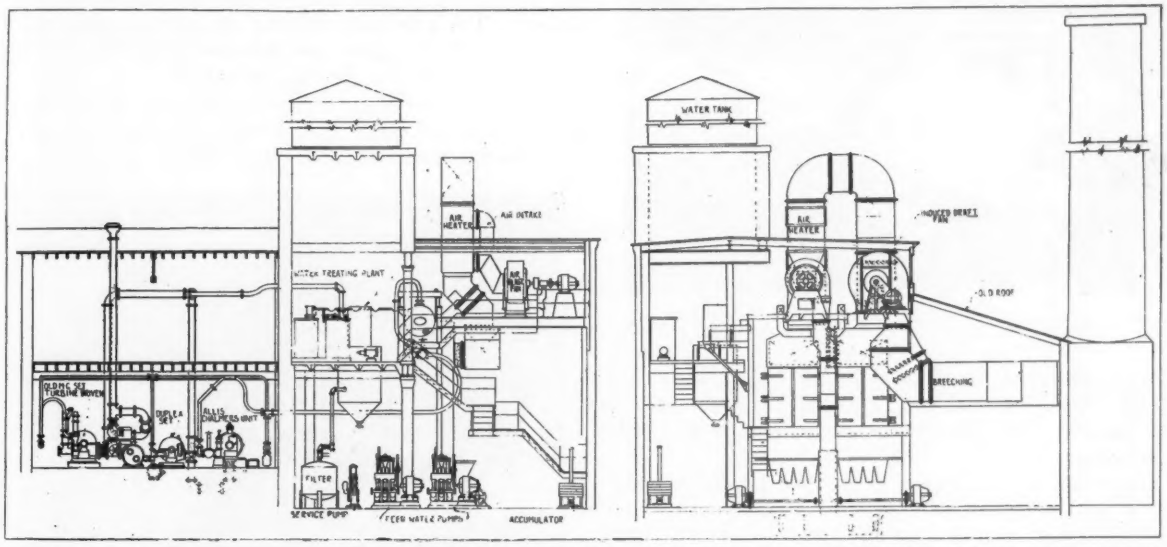


FIG. 1. BY SUPPORTING THE WATER TANK ON STEEL IN PLACE OF THE OLD BRICK WALL SPACE WAS OBTAINED FOR TWO WATER TUBE BOILERS

Steam was supplied by two standard, hand-fired 150-hp. h.r.t. boilers and draft was created by a 95-ft. brick chimney. Except for the lack of water-softening equipment, which resulted in excessive depreciation and maintenance expense of the boilers, the plant was suited to the duty for which it had been installed. Boiler feed pumps were the only steam power equipment and their exhaust was used to heat the feed water. The steam plant and electric service were in no way related.

It was determined early in 1924 after investigation of the possibilities of inter-related steam and power generation to replace the boiler plant and electric service by a 300 lb. gage pressure steam plant and a duplex alternating and direct-current electrical installation. The 1200-r.p.m., 150-kw., 440-250-v., Allis-Chalmers motor generator was left undisturbed, except that it was geared to an 1800-r.p.m., 400-hp., Terry mixed-pressure extraction steam turbine, designed to operate condensing or non-condensing at either or both pressures, or to be bled 0 to 100 per cent at 0 to 15 lb. gage pressure. The synchronous motor member of this unit, which may be designated as the "auxiliary generating unit," is rated at 100 to 125 kw. and is capable of turning over any unit of manufacturing equipment in the mill. The direct-current generating member is rated at 150 kw.

installed to provide for reserve direct current to operate the boiler plant auxiliaries in case of interruption of operation of the direct-current generating member of the auxiliary unit. This third machine is a 40-kw. compound-wound, Allis-Chalmers direct-current generator, driven at one end by a 100-hp., 100-per cent power factor, 440-v., 3-phase, 60-cycle, 1800-r.p.m. Allis-Chalmers synchronous motor and on the other end by a 150-hp. direct-connected 1800-r.p.m. Terry steam turbine, the latter being designed to operate at 300 lb. gage pressure, 200 deg. F. superheat and to exhaust against 15 lb. gage back pressure.

This unit is automatic in that its speed is maintained by steam if the voltage falls off or by the motor if steam pressure drops or the back pressure rises. Its normal duty is as a synchronous motor generator for operating the boiler-plant direct-current auxiliary motors. The first reserve duty of this unit is for idle mill duty, as its direct and alternating-current generating capacity, with synchronous motor operating as a generator, is sufficient to illuminate the mill, to operate the boiler plant auxiliaries and such essential equipment as heater fans, elevators and well pumps. The second reserve duty of the service unit is that of a final increment of generating capacity, the total of which is as follows:

Unit	Kw. A.C.	Kw. D.C.	Kw. Total
Main	500	...	500
Auxiliary	100	150	250
Service	40	40	80
Total	640	190	830

Steam requirements of the mill are from 8000 to 9000 lb. per hr. Feed water heating brings the total steam requirement up to about 11,000 lb. per hr. The excess of exhaust steam available often amounts to 5000 or 6000 lb. per hr., which, instead of being exhausted to the atmosphere, is expanded through the Terry turbine of the auxiliary unit and condensed in a Union Steam Pump Co. surface condenser by the mill water supply. This scheme affords 100 to 125 kw., thus relieving the main unit of that amount of load and bringing to a balance the steam requirements.

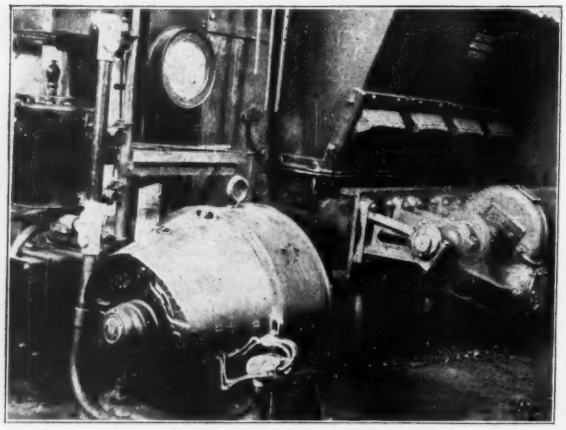


FIG. 2. EACH STOKER IS DRIVEN BY AN ELECTRIC MOTOR

Main and auxiliary generating units have direct-connected exciters of 6 and 10 kw. capacity respectively and for the service unit a separate induction motor-driven 5-kw., 250-v. generator is installed for excitation.

Old Switchboard Left Alive

The former public service switchboard was located between the auxiliary unit and the mill wall and the two pieces of apparatus were closed in a small room. The remainder of the space not constituting the turbine room was used as a machine shop. The public service switchboard was left alive and the mill run on the motor generator set until the new units and switchboard were ready for operation. The new board consists of 11 panels and was made by the Westinghouse Electric & Manufacturing Co. It is of the manual remote-control type with busses and oil circuit breakers housed in the rear.

The original well located in a corner of the boiler room and equipped with a belted motor-driven Keystone Driller plunger pump was retained in service and an additional well was drilled in the lot near an abandoned stone quarry which serves as a reservoir. The new well discharges to the quarry from which water is pumped to an overhead tank from which it flows by gravity to the surface condenser. From this condenser the greater portion of the water passes on to the mill, a portion being drawn off for boiler feed purposes. This makeup water together with the condensate from the mill and the condensate from the surface condenser are discharged into a Power Plant Specialty Co. open-type feed-water heater, rated at 600 hp. and operated at 0 to 15 lb. gage pressure. After being heated, the water passes on to a Power Plant Specialty Co. hot-process water softener and then through a sand filter of the same make. The well water contains 30 to 40 gr. of solids per gallon. The capacity of the softening equipment is 1600 gal. per hr. and of the heater 2400 gal. per hr.

Accumulator Used on the Feed Line

Three pumps have been installed for feeding the boilers. Two of these, made by the Hayton Pump & Blower Co., are 4 by 10 in. and are of the triple-plunger, single-acting, vertical type, chain driven by individual motors made by the Westinghouse Electric & Manufacturing Co. To eliminate the pulsations of these pumps, there is installed a Hayton hydraulic accumulator. The water pressure maintained is 350 lb. gage and each pump is rated at 35 g.p.m. The third pump is a 7 by 4½ by 10 in. Union Steam Pump Co. unit, which is used as a standby and for washing the boilers. It is a vertical, simplex, steam-driven unit rated at 28 gal. at 40 strokes per minute. Copes feed water regulators control the flow to the boilers.

Two Page cross-drum water-tube type boilers were placed in the old boiler room without interrupting service from the old boilers and without increasing the floor space of the room. This was accomplished first by excavating 6 ft. of bed rock and erecting a heavy structural column at the southeast corner of the tank tower, the south wall being carried on I-beams at the former roof level. These I-beams remain in place, attached to the new column, from which a new girder spans to the north wall; thus affording platform space for the feed-water heater and softener at a suitable height above the feed pumps to insure a proper suction head.

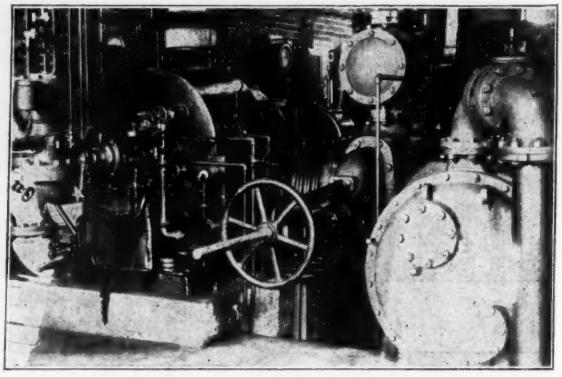


FIG. 3. STEAM FROM THE MIXED PRESSURE UNIT IS CONDENSED IN A SURFACE CONDENSER

Over the new boilers a new roof was constructed and at the new roof level heavy girders support the tank tower, the east well of which thus overhangs and clears one of the new boilers. These boilers are rated at 2302 sq. ft. each and 300 lb. gage working pressure. They are fitted with Johns-Manville baffles, Edward stop and check valves, Williams water columns, Everlasting tandem blowoff valves, Crane high-lift safety valves, Crosby steam gages, Lagonda tube turbines, Tracy purifiers, Bayer balanced valve-in-hand soot blowers and Power Specialty Co. Foster superheaters, each rated at 2300 sq. ft. of heating surface to give 200 deg. F. superheat at 125 per cent of boiler rating.

One Combustion Engineering Corp. air preheater of 1508-sq. ft. heating surface serves both boilers. This heater

projects about halfway through the roof and takes air from the boiler room ceiling. This heater supplied with 30,000 lb. of gas at 525 deg. F. will raise the temperature of 28,000 lb. of air from 70 to 242 deg. F. The exit gas temperature will be 365 deg. F. The draft loss in the gas passage is 0.3 in. of water and that of the air passage 0.90 in. of water. The flue which was constructed by William Heggie and lined with 1½ in. of Johns-Manville fire backing and plastered smooth inside with their hot blast and plastic refractory cement, is arranged with dampers so that the preheater may be bypassed and in either case the gases may be handled by a No. 100 single width Clarage steel plate induced draft fan, or the fan may be bypassed and gases may go to the chimney by natural draft either through or bypassing the preheater. The induced draft fan which is driven by a 15-hp. Westinghouse motor

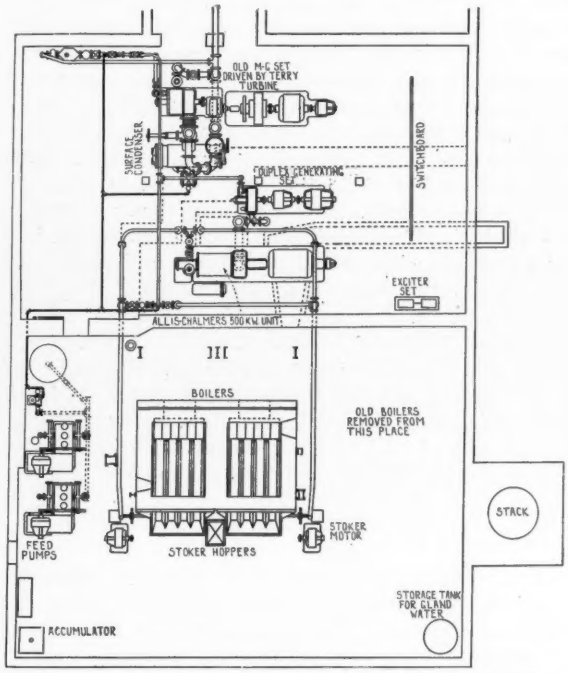


FIG. 4. TWO OLD BOILERS WERE KEPT IN OPERATION DURING THE PLACING OF THE NEW WATER TUBE BOILERS

through an enclosed Link-Belt Co. silent chain discharges the waste gas into the old brick chimney which is 6 ft. in diameter and 95 ft. high. The forced draft fan is driven directly by a 20-hp. Westinghouse motor.

Both fans are mounted on a platform just under the roof and the forced draft duct extends downward in front of the center of the battery of boilers. Branch ducts convey heated air from the main blast duct through hollow setting walls furnished by Liptak Fire Brick Arch Co. and erected by Edward Nelson, boiler setting contractor of Chicago. The heated air from the branch ducts is introduced into the fire through Bernitz Furnace Appliance Co. hollow perforated carborundum injection blocks. Fire brick is of A. P. Green make and insulation against heat conductance outward from the hollow wall pass was supplied by Celite Products Co.

Horizontal four retort underfeed stokers were furnished by the Detroit Stoker Co. and have a width of 6 ft. 3 in. each. They are equipped with hand-operated rear dump plates and are separately chain driven by means of Westinghouse motors. Illinois screenings of 8 to 12 per cent moisture, 30 to 35 per cent volatile matter, 45 to 50 per cent fixed carbon and 10 to 15 per cent ash are burned. The coal averages 10,000 B.t.u. as fired and the ash fuses above 1900 deg. F. Ash is raked out by hand into wheelbarrows at the rear of the setting. The mud drum is insulated by air enclosed in a box built of steel channels which in turn is insulated by segments of Liptak single suspension arches made by A. P. Green Fire Brick Co.

In addition to the equipment and materials listed above, the following was furnished: Durametallic gaskets,

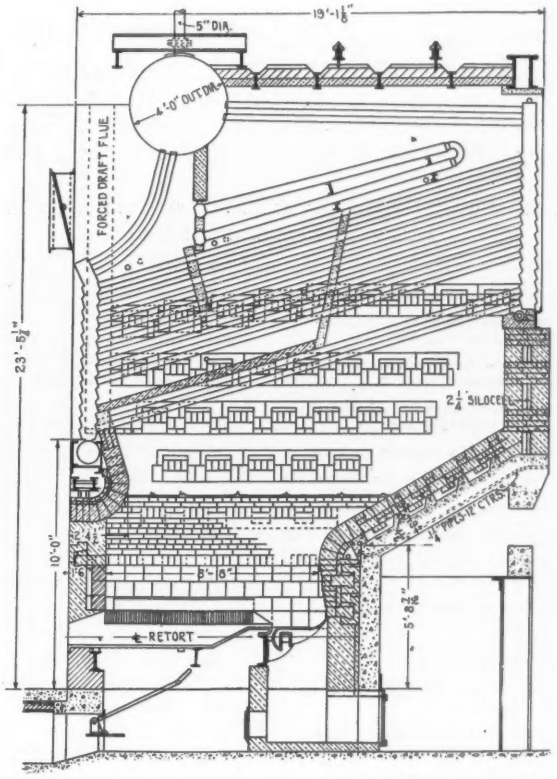
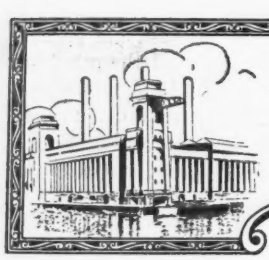


FIG. 5. FURNACE WALLS ARE AIR COOLED AND AIR IS ADMITTED OVER THE FIRE THROUGH INJECTOR BLOCKS

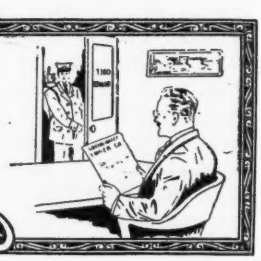
Wheeler Condenser and Engineering Co. expansion joints and steam jet air pump and Johns-Manville Inc. and Philip Carey Co. insulation. Valve and piping equipment, erected by D. H. Skeen and Co., was furnished by the Pittsburgh Valve, Foundry and Const. Co., Walworth Mfg. Co., Crane Co., Edward Valve and Mfg. Co. and M. J. Dougherty Co. Traps were furnished by the Andrews-Bradshaw Co., Armstrong Machine Wks. and Hoffman Specialty Co. Miscellaneous steam specialties were furnished by the Cochrane Corp., Boylston Steam Specialty Co., D. H. Skeen Co., Fisher Governor Co., The S-C Regulator Mfg. Co. and the Swartwout Co.

Small pumping equipment was furnished by the Economy Pumping Machinery Co. Steam flow, air flow and CO_2 recording meters were furnished by the Republic Flow Meters Co. and recording pressure gages and thermometers by Taylor Instrument Co.'s The heat exchanger for the gland sealing water was made by Griscom-Russell Co. All conduit, fittings, cable and wire was made by the Western Electric Co.

This mill is under the personal supervision of Thompson Smith, president of the company. George Roschek is superintendent and James H. Kraus is engineer.



LETTERS DIRECT FROM THE PLANT



Heat Loss in Flue Gas Measured by Using Economizer as Calorimeter

As DESCRIBED in the March 15 issue, Mr. Thornton's method of using the economizer as a calorimeter for measuring the heat loss in flue gases is ingenious but it fails to take into account the air leakage of the economizer setting, which dilutes and lowers the temperature of the flue gases and in most cases would render his results quite misleading. It is also difficult to get the average temperature of gases leaving an economizer. With two thermometers at the same point in the flue, I have seen one thermometer placed 4 ft. above the other read 50 deg. higher, owing to vertical stratification of the gases. Since this method is based on temperature differences, such errors will affect materially the final results.

TABLE SHOWING FLUE GAS ANALYSIS AND TEMPERATURE DATA FROM FOUR ECONOMIZERS

Plant	A1	A2	B1	B2
Boiler room temperature deg. F.	90	90	71	71
Flue gas temperature leaving boilers deg. F.	463	468	--	--
Flue gas temperature entering economizer deg. F.	402	426	421	416
Flue gas temperature leaving economizer deg. F.	211	241	255	248
Per cent CO_2 leaving boilers	11.9	13.2	--	--
Per cent CO_2 entering economizer	8.1	9.3	7.8	7.5
Per cent CO_2 leaving economizer	4.5	6.2	7.3	6.3
Per cent excess air leaving boilers	68	47	--	--
Per cent excess air entering economizer	142	117	147	171
Per cent excess air leaving economizer	418	222	168	216
Feed water temperature entering economizer	172	172	118	118
Feed water temperature leaving economizer	202	216	194	168
Heat of flue gases entering economizer - per cent of coal	13.9	13.6	16.0	17.1
Heat of flue gases leaving economizer - per cent of coal	11.1	8.8	9.0	10.1
Heat given up in economizer - per cent of coal	2.8	4.8	7.0	7.0
Heat absorbed by water - per cent of coal	2.1	2.9	4.8	3.5

Some results obtained in power plant testing are given in the accompanying table, the gas analysis being obtained from simultaneous gas samples using two Orsats and the temperatures by reading pyrometers at the time the sample was taken, the tests extending over several hours. The gas analysis and temperatures from the boilers were obtained under similar conditions, but not simultaneously with the economizer figures. Each plant had two economizers for separate banks of boilers, designated 1 and 2, and tested separately.

From these data, it will be seen that even a moderate amount of air leakage, with tight settings under the best conditions, will make a considerable difference, if temperatures alone and not composition of flue gases are considered.

Following is a simpler method of estimating stack losses, more accurate than Mr. Thornton's and not limited to boilers equipped with economizers. Air is not usually considered a fuel but, since it combines with carbon and hydrogen in certain definite proportions, there is no reason why heating values should not be figured in B.t.u. per lb. of air, which then become, for carbon, $14{,}544 \times 12/32 \times 0.2375 = 1295$ B.t.u. per lb. air and for hydrogen, $62{,}100 \times 2/16 \times 0.2375 = 1843$ B.t.u. per lb. air. It is noticeable that this puts the carbon and hydrogen more nearly on an equal basis. If we consider an average eastern coal having a ratio of carbon to available hydrogen of 20 to 1, we shall get a heating value for the combustible of about 1321 B.t.u. per lb. air. Such coals require a theoretical air supply of about 10 lb. air per lb. coal, so that the products of combustion, including moisture evaporated and that formed by the combustion of the hydrogen, will give about 1.1 lb. products of combustion per lb. air. Now, taking an average specific heat of 0.24 to cover the moisture content, the heat required to raise this weight of gas 100 deg. F. will be

$$\frac{1.1 \times 0.24 \times 100}{1321} = 0.0200$$

or 2 per cent of the heating value of the air. Since this is the same as that of a corresponding amount of coal, this will be 2.06 per cent of the heating value of the coal also.

Similarly the excess air supplied to insure complete combustion and that leaking in at various points in the system, can be figured from the gas analysis by the formula: Per cent excess air

$$= \frac{\text{per cent oxygen (by volume)}}{\text{0.2645 per cent nitrogen—per cent oxygen}}$$

$$= \frac{1.0 \times 0.2375 \times 100}{1321} = 0.0180 \text{ or } 1.80$$

per cent of heating value of the coal for 100 per cent excess air and in direct proportion for other percentages. The exact B.t.u. content of the coal need not be determined.

By means of these formulas it is necessary to know only the flue gas temperature and flue gas analysis to obtain an estimate of the flue losses sufficiently accurate for most purposes, as these constants have been checked against the values found by the standard method on the heat balances of a large number of boiler tests and found accurate within 5 per cent of the quantities themselves, which is usually as dependable as the test observations and sampling. For other coals having a different ratio of available hydrogen and carbon and different air per lb. for combustion, the corresponding heating value per lb. of

air and constant for flue loss can be worked out, but the differences are so small that they can be neglected for ordinary work.

These formulas present the information in a convenient form, for while in Plant A, from a temperature standpoint alone, Economizer No. 1 might appear to be doing much better work than No. 2, yet it will be seen that the low exit temperature is due to air dilution and the heat carried away is greater than at the higher temperature shown by No. 2. The same holds for the comparison of boiler performances, because changes in stoker operation can readily be compared in their effect on flue losses.

Ashpit losses can be computed by the formula

$$\frac{C \times A \times 14{,}544}{(100-C) \times \text{approximate B.t.u. of coal loss}} = \text{per cent ashpit}$$

Where C = per cent combustible in refuse by analysis
A = per cent ash in coal as fired

By comparing these losses, a fair check of their effect on general operating economy can be obtained without expensive tests, elaborate heating value determinations or ultimate analysis of the fuel.

New Haven, Conn. H. D. FISHER.

Drying of Coal for Pulverizing

IN THE April 15 issue appeared an article that I prepared entitled, "Drying of Coal for Pulverizing." In order to present to readers of this article a more complete idea of the difference between surface moisture, intrinsic or seam moisture and chemically combined moisture, an explanatory paragraph should be inserted immediately after the sentence in paragraph 4 on page 422, which reads as follows: "The reason seemingly high moisture lignites or sub-bituminous coals may thus be burned when Eastern or Mid-West bituminous could not be successfully handled with anywhere near such percentages is due to the fact that a large proportion of the lignite moisture is either inherent or chemically combined rather than surface moisture."

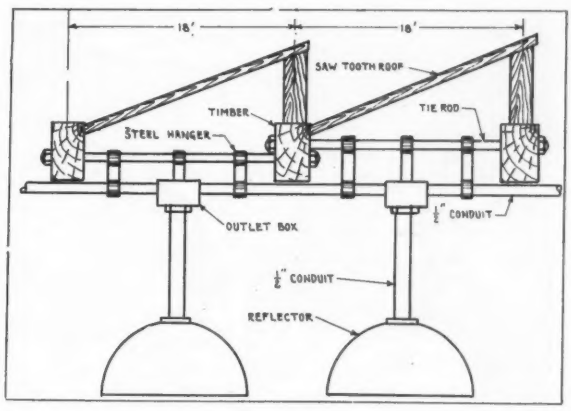
The following paragraph should now be read: Surface moisture occurs on the outside of the lumps of coal and originates either from rain, snow or ice, when the coal is exposed to the weather, or from underground water trickling over the surface of the exposed seam when in the mine. It may be easily removed by short air or waste gas drying. Intrinsic or seam moisture occurs within the coal cells inside the lump and is characteristic of the coal principally because the colloidal condition of a coal changes with its geological age. It is characteristic of colloidal substances like coal to retain cellular water, hence the lignites and sub-bituminous coals which are more colloidal in their nature retain more water than less colloidal substances, such as straight bituminous coal and anthracite. This intrinsic or seam moisture (or colloidal water) has a lower vapor pressure, therefore it requires a higher temperature and more air or waste gas circulation to remove. Correspondingly that portion which remains after passing through the dryer as above indicated will cause no difficulty in the pulverizing or transport system. Chemically combined moisture is a part of the coal substance itself, is also characteristic of the coal and is not liberated until sufficiently high temperatures are reached that decomposition sets in and liberates at the same time combustible gases.

At the end of the article the following paragraph should be added: Lack of uniformity in dryness has been observed to require as high as a 30 per cent change in feeder speed to maintain a constant evaporation, other conditions remaining the same. Naturally, therefore, furnace conditions are improved with the more constant rate of coal feed only assured through dryer operation. Combustion also is improved, for less heat is absorbed by the evaporation of excess moisture within the furnace where it is most needed for producing high flame temperatures, hence maximum temperature heads between flame and tubes which result in maximum heat transfers and efficiencies.

Fullerton, Pa. H. W. BROOKS.

Electric Conduit Was Fastened to Roof

IN A NEW manufacturing building, which has a saw-tooth roof, it was desired to suspend electric lights from the ceiling throughout the building. The wires had to be run in iron conduit but, on account of the saw-tooth roof



HANGER BANDS FROM TIE RODS HOLD CONDUIT RIGID

construction, it seemed at first a difficult matter to fasten or hold the conduit and light fixtures. The method shown in the sketch, however, made a neat and rigid job.

It will be noticed in the illustration that there are timbers running across the building which support the roof. These timbers are held in place by tie rods as shown, with a span of 18 ft. between the timbers. The ½-in. conduit was fastened to the timbers with pipe clamps, then suspended from the tie rods in each section with three steel hanger bands, as shown, clamped over the tie rods and the conduit.

Milwaukee, Wis. H. A. JAHNKE.

Coal Costs Should Be Properly Distributed

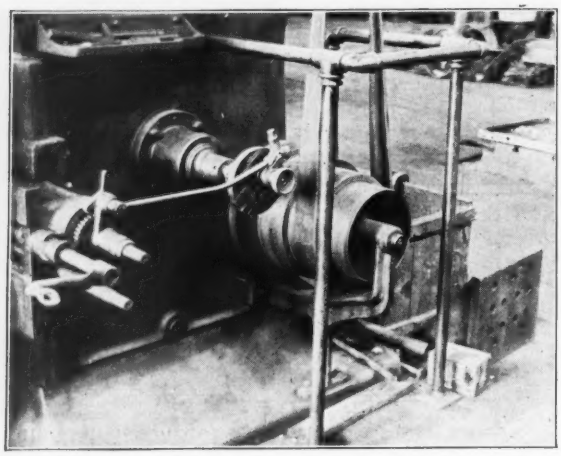
HOW SHOULD standby coal be charged in a factory steam plant? The solicitor for the central station would no doubt be in favor of charging it all to power. But in our case, and no doubt many others, this would be decidedly unfair. Practically half the steam is used for process work. This should stand its share of the burden also. We supply steam to heat two residences 24 hr. a day during the heating season and water the year around. Considerable water is pumped during the time the shop is shut down that might possibly be charged to power, but in reality little coal is used in this way, as the exhaust is turned into

the heating system, thereby saving an equal amount of live steam. During the warm months, not so much pumping is required. During the colder months, the shop is heated in daytime by exhaust from the engine. It seems to us that some of this burden should be charged to this heating. Fire insurance regulations require us to keep steam up at all times to operate the fire pump in case of necessity. Taking into consideration that we could, as far as power is concerned, bank our fires over night and let them go out over week ends, it appears to us that the amount of coal chargeable to power standby loss is small. We would like to have someone comment on this.

Anderson, Ind. J. O. Benefiel.

Pulley Guard Should Be Simple

Guards for pulleys near the floor and for belts driving them are often inadequate to furnish the protection desired. On the other hand, if they are unduly complicated or



THIS PULLEY GUARD GIVES PROTECTION BUT DOES NOT HAMPER WORKMEN

clumsily built, they may impede work on the machine or around it and may even become sources of danger themselves. A pulley guard made of pipe fittings, however, as shown in the illustration, will furnish sufficient protection to the workman, will be neat in appearance and will not interfere too much with the operation of the machine.

Missouri Valley, Ia. Frank W. Bentley, Jr.

Questions for the Power Plant Helper or Fireman

We have seen list after list of examination questions for engineers printed in the engineering journals. But a list of questions to ask the man applying for a job as fireman or helper, who has little or no school education and who cannot solve even simple mathematical problems, is not so easy to find. As chief engineer in large power plants, I often used such a list of questions when employing this type of labor, more or less skilled, for the engine and boiler rooms and workshops. There are hundreds of fairly good mechanics working in power plants who have had a little schooling in their youth, but who have had small opportunity to get further education.

If you hand such a man several sheets of paper and request him to write out answers to your questions, he often becomes confused, although in actual work in the plant he may be a good man, with ability to handle tools or to fire a boiler and with fairly good judgment. By talking to such a man for a few minutes about engineering in general, however, you can put him at his ease. You can then tell him you are going to ask him a few questions about the plants he has worked in and ask him to answer them to the best of his ability, according to what he has seen and done himself, just as he would discuss them with some fellow worker.

Following are some typical questions I have often asked in such cases. The idea is to find out as nearly as possible what the man actually has done and can do. After asking a few introductory questions about the kind and size of equipment the man has been working on, you might ask such questions as these:

How would you fire up a new furnace, fire-brick lined, the boiler also being new? Do you leave the damper open or shut while you are working with the furnace doors open? Do you understand the difference between foaming and priming in boilers? How often would you blow out the water glass and test the connections? How would you bank a fire with coarse soft coal? How often did you clean out the boilers where you last worked? What process would you use in laying up a fire-tube boiler for some months? What would you do if the pump got so hot that it would not pump water? Is it good practice to empty a boiler while the brick work is fairly hot?

Any man who can give satisfactory answers off-hand to such questions is almost certain to be a fairly good helper as far as useful knowledge is concerned. Of course, a man's ability to handle tools properly and to use his brains in an emergency can be determined in only one way, during actual work.

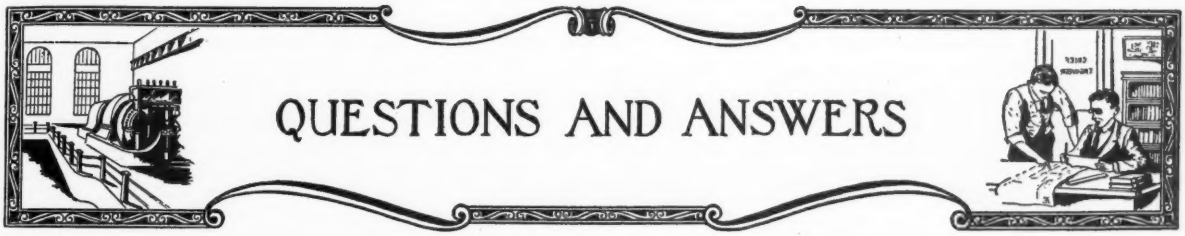
Toronto, Ont. James E. Noble.

Why Not Publish Prices?

I never have been able to understand why publishers of catalogs are so careful about omitting prices from them. They will pack the catalog full of words about the history, manufacture, uses, advantages, appearance, weight, strength, dimensions, length of life and everything else—but they don't give prices. All of these things are important, of course; prospective purchasers want to know as much as possible about the things they are going to purchase. But what interests the average purchaser more than anything else is: How much will it cost? He looks for the price, can't find it and immediately thinks, "The price is so high that they are ashamed to print it"; thereupon he throws the catalog aside and proceeds to forget the matter.

Many sales are lost because of this practice of omitting the price. True, a letter can be dictated or written, inquiring about the price; but that requires initiative, time, effort and money. Furthermore, if the publisher of the catalog is located at a considerable distance away from the prospect, it may take a week or more before a reply is received and by that time the prospect probably has spent his money for something else or has forgotten about his needs and has lost interest; therefore it is up to the publisher of the catalog to rekindle the prospect's interest, which means that his chances to make the sale are materially reduced.

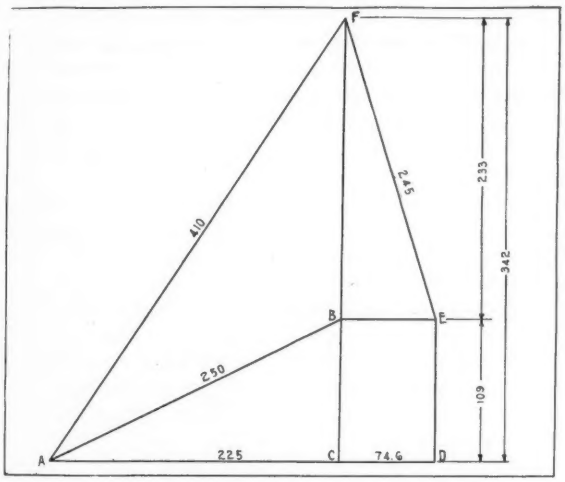
Newark, N. J. W. F. Schaphorst.



QUESTIONS AND ANSWERS

Synchronous Motor Designed to Take Load and and Raise Power Factor

Our present electrical load is 225 kw., but we also have an ammonia compressor operated by a 100-hp. steam engine. We wish to drive this compressor with a synchronous motor that will at the same time raise the power



VECTOR DIAGRAM, SHOWING RELATION BETWEEN LOAD, REACTIVE COMPONENTS AND SYNCHRONOUS MOTOR CAPACITY

factor of our system from its present value of 55 per cent. to 90 per cent. How can we find the proper size of synchronous motor? M. H.

A. Reference to the accompanying vector diagrams will show how this is found. Let us consider first the question of raising the power factor from 0.55 to 0.90, without adding the load.

With a load of 225 kw. and a power factor of 0.55, the apparent load is

$$\frac{225}{0.55} = 410 \text{ kv.a.}$$

An actual load of 225 kw. with an apparent load of 410 kv.a. has a lagging reactive component as follows:

$$\sqrt{410^2 - 225^2} = \sqrt{117{,}475} = 342 \text{ kv.a.}$$

On the diagram, AC is laid off to scale to represent 225 kw., AF to represent 410 kv.a., and CF, perpendicular to AC at C, to represent 342 kv.a. CF, then, represents the amount of lagging power at 0.55 power factor.

Now at 0.90 power factor, the apparent load is

$$\frac{225}{0.90} = 250 \text{ kv.a.}$$

The lagging reactive component equals:

$$\sqrt{250^2 - 225^2} = \sqrt{11{,}875} = 109 \text{ kv.a.}$$

AB to scale represents 250 kv.a. and CB, 109 kv.a. CB is the lagging power at 0.90 power factor.

Now if we introduce into the circuit a synchronous motor, with its excitation properly adjusted, we can cause it to produce a leading kv.a., which will counterbalance some of the lagging kv.a. In other words, if we use a synchronous motor of 342 — 109 = 233 kv.a., we can reduce the lagging component from 342 to 109 kv.a. and thus raise the power factor of the circuit to 0.90.

Such a motor, however, would not be taking any load; it would do nothing but generate wattless power. If we add 100 hp. or 74.6 kw. to the load, represented by CD = BE, the motor must develop this amount of direct power in addition to the wattless power FB = 233 kv.a. necessary to correct the power factor. The motor then must have as its total capacity the resultant of these two vectors, that is:

$$\sqrt{74.6^2 + 233^2} = \sqrt{59{,}900} = 245 \text{ kv.a.}$$

For these conditions, a synchronous motor of 250 kv.a. capacity would probably be selected.

Indicator Diagram Shows Valve or Piston Leakage

ENCLOSED is an indicator diagram from a 20-in. by 30-in. Corliss engine, running at 150 r.p.m. and driving a 500-kv.a. alternator. This engine is 60 ft. from the boiler,

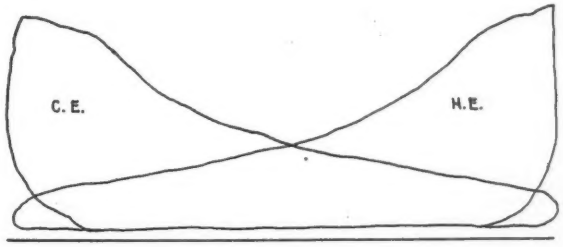


DIAGRAM FROM 20-IN. BY 30-IN. CORLISS SHOWS EXCESSIVE STEAM LINE DROP AND STRAIGHT EXPANSION LINE

the main steam line being 7-in. pipe with three 90 deg. bends in it. Please comment on this diagram and also tell me if there is likely to be too great a pressure drop between boiler and engine. C. H. S.

A. On this diagram, the principal fault seems to be the excessive pressure drop shown on the steam line. Then, too, the expansion line is almost straight, during the last half of the stroke, the pressure at release being too high.

From the general appearance of these lines, we conclude either that there is a bad leak through the admission valves or that the piston is leaking so badly that steam blows right through from one side of the piston to the other as soon as it has been admitted. Leaky exhaust valves might, of course, cause the excessive drop on the

steam line; this drop might also be due to an excessive drop in pressure on the main steam line.

You can determine whether the latter is the case or not by taking a steam chest diagram. To do this connect the indicator piston to the steam chest instead of to the cylinder, arranging the reducing mechanism so that it will give the same stroke as it did when attached to the cylinder. You will get a strange looking card showing the relation between steam chest pressure and the stroke of the engine. Use the same indicator spring to get the steam chest diagram that you used for the cylinder diagram.

Now, by superimposing this steam chest diagram on the cylinder diagram, you can see whether or not the excessive drop shown on the steam line is accompanied by a large drop in the steam chest pressure. If so, the trouble is probably between boiler and engine. We are strongly inclined to the belief, however, that your engine has leaky valves, a leaky piston or both.

As to the setting of the valves themselves, it appears that admission and release are both late. The inward slope of the admission line on each end indicates the former; possibly more steam lead would improve it.

Compression seems to occur too early; it can occur later when running non-condensing than when running condensing. By giving more steam lead and earlier admission, you should have sufficient steam in the cylinder for proper cushioning at the end of the stroke. Naturally you should get a much sharper cutoff with a Corliss gear than this diagram shows, but the bad leakage of steam probably causes the excessive rounding at this point.

Oil and Grease Extraction From Exhaust Steam

SOME OF the following hints may assist A. P. N. to overcome the trouble he describes in the April 1 issue. First of all, why use such a large amount of cylinder oil (either compounded or straight mineral oil) that there will be an appreciable quantity in the exhaust steam? Perhaps he has not a mechanical force feed lubricator by means of which he could regulate and control the amount going into the cylinder or cylinders, as the case may be. If that is so, then it will pay, in the long run, to obtain one.

Let him use the minimum quantity of oil that will lubricate the internal parts of his engines satisfactorily. There is such a thing as a minimum, when it is considered that there are engines that get no oil at all for internal lubrication, except for the little that may get into the cylinder from swabbing the piston rods with cylinder oil.

Then again, why take it for granted that he must use a compounded oil? Of course, it is much more difficult to extract a compounded oil from condensate than to extract a straight mineral oil. If he can try a straight mineral oil of high grade, he may have to use a little more of it than would be required with a compounded oil, still a controlled feed will go far to solve the problem. If his steam is wet and he must, under the conditions, use a compounded oil, why not take steps to obtain dry steam, or at least steam less wet than he thinks it is at present? I suggest, therefore, that the following things be done.

A good mechanical force feed lubricator should be connected to the steam line, through an atomizer, some little distance back from the engine throttle or stop valve, so as to give the flowing steam a chance to break up the drops of oil and mix it with the steam. The feed of oil should be controlled so that only the minimum amount necessary for lubrication will be introduced. A mineral oil of good quality should be used and, if possible, steps should be taken to obtain dry steam in the first place. An ordinary louvre type of grease extractor should be placed in the exhaust pipe, close to the cylinder exhaust exit and the cloth filters and settling tank with goose-neck pipe connections should be continued as at present.

With the accomplishment of all these things, it is not likely that any oil will be discovered in the exhaust steam condensate. The cost of doing all that I have suggested may not be small for an initial outlay, but the saving that will accrue, besides removal of oil from the condensate, will soon wipe out the cost, while the economy will continue indefinitely.

Brooklyn, N. Y. CHARLES J. MASON.

IF A. P. N. will consult any of the large oil companies about the problem of extracting oil from his exhaust steam as described in the April 1 issue, he can probably get some good advice from them as to the proper methods of lubrication and the best oil removing equipment for his conditions.

Various refrigerating plants throughout the country operate steam-driven compressors and use the condensate from them for the water supply to their ice cans. Such plants have solved the problem of taking out the oil; from this exhaust condensate they make ice so clear that a newspaper can be read through it. In plants of this nature, reboilers and special types of oil and water separators are used. Consultation with some of the refrigerating engineers should yield A. P. N. considerable information about how they do it.

Without knowing the steam pressures, type of engines or turbines, or any other data, it might be suspected that too much oil is being used under improper lubrication conditions whereby the oil is not thoroughly atomized by the steam. Of course, if a straight mineral oil could be used instead of a compound oil, much of the trouble might be prevented.

Galveston, Tex. H. W. ROSE.

Leakage at Handhole Plates

AT ONE TIME I had trouble with leaking handhole plates similar to that described by H. R. W. in the April 1 issue. These caps were of the outside type, so at cleaning time we smoothed the surfaces of the caps and header seats with fine emery paper. Then under each cap we put a gasket of asbestos paper, cut into a disk about 1 in. greater in diameter than the cap, with a hole punched through the disk for the bolt to go through. These gaskets proved most satisfactory.

On another job, we had boilers with inside header caps, using copper covered asbestos gaskets. We never had any trouble with these. In using them, however, care should be taken to use each gasket only once. If there is the slightest dent in the copper of a new gasket, don't use it at all.

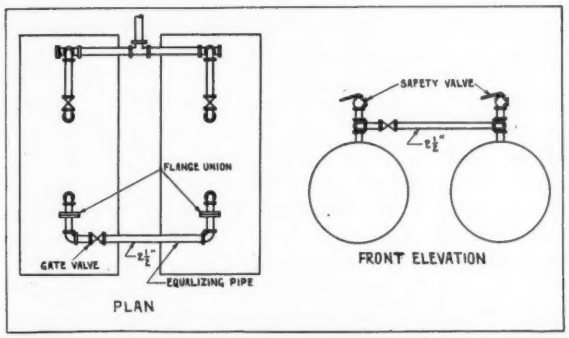
Often a manhole gasket will leak. I have prevented this by passing several turns of candle wicking around the flange of the cover so that the wicking made a pile close to the shoulder. Then, when the gasket is placed on this

pile, covered with oil and graphite, and the cover screwed tightly in place, there should be no leakage.

Rochester, N. Y. R. G. SUMMERS.

Why Does One Boiler Take All the Returns?

IN THE March 15 issue is a low-pressure heating problem entitled "Why Does One Boiler Take All the Returns?" Attached is a sketch showing a method of connecting two boilers together with an independent pipe which is known as an equalizing pipe. Where conditions will permit, a tee having the same size outlet as the safety valve inlet is connected to the safety valve outlet of each boiler. The side outlets of these tees are connected by a pipe of suitable size, which is usually the size of the safety valve inlet. According to the information given on this particular problem, a 2½-in. pipe would be sufficient. This pipe is connected to each tee with two flanged unions and a gate valve. The two flanged unions make more convenient and less rigid piping connections between the safety valve outlets of the boilers. The gate valve should be closed when only one boiler is in operation; when both boilers are in operation, the gate valve should be wide open.



EQUALIZER PIPE CONNECTED AS SHOWN WILL EQUALIZE RATES OF EVAPORATION

The principal cause of the returns flowing to only one boiler when both boilers are under the same pressure, may be that for several reasons one of the boilers absorbs more heat from the fuel than the other, with the result that the boiler having the most heat will evaporate the most water. As there is only one place for steam to escape on each boiler—through the steam nozzle into the heating main—the result is that the boiler evaporating the most water has the greater pressure which prevents the check valve from opening on the return pipe connected to that particular boiler, so that the boiler that is doing the least evaporating is receiving most of the returns.

New York. A. B. JONES.

Settings for Return Tubular Boilers

IN THE April 1 issue under the above title, A. B. asks opinions on how high they should be set from the grate to get best results.

In the plant where I am employed, we installed two 72-in. by 18-ft. return tubular boilers last summer and set them 6 ft. 3 in. from the grates. These two boilers have taken care of all the load this winter, where as before we always operated four and five boilers during the heating season. The bridgewall was originally made 56 in. high. We have since taken three courses of brick off the bridgewall and the results have been better. With the higher bridgewall the temperature of the furnace was so high that the arch melted, the doors warped and the heat was not distributed over the shell as evenly. We use underfeed stokers. From my experience with different heights of settings, I would recommend setting the boilers 6 ft. from the grates.

Toledo, O. RALPH CUPPS.

IN HIS question regarding settings for H. R. T. boilers, in the April 1 issue, A. B. says nothing about the kind of fuel he is using. This would have an important bearing on the amount of combustion space required under these boilers. It would also influence the size of the stack and would determine the type of grate bars, if hand firing is used.

For a boiler of this type, a common rule is to make the height from the level of the ash pit to the bottom of the boiler about 6 ft., closing in the side walls at the average water line of the boiler. If the brickwork is carried above this line, the heat may injure the boiler; if the brickwork is capped off below the water line, heating surface is lost. The bridgewall generally projects from 6 in. to a foot above the grates. In most plants, however, this height is determined by tests for the individual plant; the bridgewall may even extend to within a foot of the shell. The back arch construction also should not be neglected.

Galveston, Tex. H. W. ROSE.

IN THE April 1 issue, A. B. asks how high his 72-in. by 18-in. H. R. T. boilers should be set above the grates.

Placing the boilers several feet above the grates may tend to better combustion results; but with an ordinary return tubular boiler setting, the greater the height the greater the loss of heat from the side walls and the less benefit from absorption of heat by direct radiation from the fire to the under side of the shell. For average fuel and hand firing, the best results in over-all fuel economy are usually obtained from 72-in. boilers when they are set from 30 to 36 in. above the grates. My reply is based upon personal observation in ordinary boiler room practice. With extraordinary and unusual care used in constructing the walls, better results might be obtained with higher settings.

Toronto, Ont. JAMES E. NOBLE.

Discharge of Sprinkler Head

HOW MUCH water is discharged through a sprinkler head with a ½-in. orifice, the water pressure being 95 lb. per sq. in.? J. P. M.

At a pressure of 90 lb. per sq. in. a sprinkler head with diaphragm or ring nozzle having a ½ in. orifice should discharge about 55 gal. per min. At 100 lb. pressure, the discharge should be approximately 58 gal. per min. Therefore, at 95 lb. pressure, the head should discharge between 56 and 57 gal. per minute.

With the average open sprinkler using smooth bore conical nozzles, pressures up to 50 lb. per sq. in. are used. At this pressure, a nozzle, ¼ in. in diameter, will discharge about 11.5 gal. per min. and a ⅜-in. outlet will discharge about 24.3 gal. per min.

EDITORIAL COMMENT

That Coal Storage Problem

One of the principal reasons why coal is not more generally stored by industrial concerns is because the advantages of so doing have not been studied and rational conclusions reached. It is a subject that requires individual study and must therefore be based in a great measure upon the conditions which the engineer meets within his own jurisdiction. It is not a problem which should be lightly set aside by the mere expression of an opinion, because in its entirety it affects the whole economic structure of coal production, transportation and distribution and also the quantitative production of American industry.

This problem is not merely one of producing steam when it is convenient to do so, but rather to produce steam when required and in sufficient quantity to meet the demands of the market for manufactured products. It seems rather incoherent to spend a large sum to provide a power plant and then not to do everything possible to provide an assured supply of coal, which is so essential to its operation.

Recent studies of this problem by the American Engineering Council have been exceedingly thorough. The conclusions reached are that coal consumers should purchase their coal requirements on an annual contract, that contract to cover their yearly requirements. This arrangement would of necessity require that storage facilities, such as ground space and coal handling equipment, be provided.

It appears as if this arrangement would result in the coal mines being able to inaugurate a regular production schedule, thus eliminating the fluctuations of labor employment now current in the coal fields. The cost of coal production would be cut through the operation of only about half the number of mines which must be equipped and maintained under the present order of things.

This plan would materially help the carriers in that they could lay out schedules for equipment and its movement. Stocks of coal would automatically accumulate during the months from April to September and this accumulation would be a big factor in meeting the extra consumption of coal during the winter months. The net result of inaugurating this practice would be a reduction in the price of coal to the consumer through the elimination of peak demands in the winter months, when the costs of both production and transportation are the highest and when there is also the greatest possibility of the transport system breaking down or proving inadequate to meet the unreasonable and unnecessary demands placed upon it.

It is at once apparent that this problem cannot be initiated by either the coal producers or by those who are responsible for its transportation. The initiative must be taken by the consumer for he is the one who creates the demand for coal. It is futile to point out the comparatively few instances where coal storage is now practiced. The benefits to be expected from the proper storage of coal will come only when the vast majority of power plants put it into effective practice.

Furnace Design for Wood Refuse

For some time past, the use of wood refuse as a fuel has been increasing and plants that have been able to avail themselves of it are now fully aware of its value in the never-ceasing battle to obtain lower power costs. In one case, even, a central station designed to serve a city of 150,000 in the Northwest will burn wood refuse entirely. Industrial plants in particular often have available considerable quantities of wood refuse from their manufacturing processes. In the majority of cases, success in burning this fuel economically depends to a large extent on proper furnace design and we feel that the importance of this cannot be emphasized too strongly or too often.

Design of a furnace for burning wood refuse naturally depends or should depend on the kind of wood used and particularly on its moisture content. Above everything else, ample furnace volume and proper design for complete combustion and for thorough mixing of the gases are the desirable characteristics of such a furnace. It would seem that such things should be obvious to the designer or operator, but often they are not. In a recent case of furnace trouble that has come to our attention, the furnace and grates were apparently designed to burn hogged fuel containing considerable moisture. Instead of using hogged fuel, however, this plant used a mixture of kiln dried hardwood sawdust and shavings, which burned in suspension as it left the mouth of the feeding spout. The longer flame and higher temperatures thus attained caused serious trouble with the refractories. As a contrasting case, another plan not far away used almost the same type of fuel, but burned it in suspension in a furnace of about 10,000 cu. ft. capacity under a 1300-hp. boiler, with no trouble at all.

It is no more safe, however, to lay down dogmatic rules for the design of wood refuse furnaces than it is to generalize about furnaces burning various types of coal. There are, of course, fundamental rules of combustion in either case; but although some conditions may be the same in one plant as they are in another, there may be just a few differences in details that will modify the entire design. Each case should be decided finally on its own merits. If this is done in a plant that has wood refuse available, even though it forms only a part of the total fuel burned, splendid results may be obtained and the power costs lowered appreciably.

Propaganda Is Hindering Engineering Progress

Solution of engineering problems has always been and always will be a matter of individual investigation; that is, no blanket conclusions can be reached no matter how promising they may seem. This is a fact which is readily appreciated by the thinking engineer, for he has often grasped at some promising idea, only to have to discard it

because it could not be used economically under the conditions which he must work and plan.

Thus, as far as the engineer is concerned, widespread propaganda has little or no effect; but when these propositions are placed before the public, the reaction is of an entirely different kind. A great amount of good can be accomplished by giving the engineering profession the publicity which it deserves. Other professions have grasped at every opportunity to gain widespread publicity and there is no more than occasional evidence that this move has created any other than a favorable reaction.

Publicity on engineering undertakings should be given to the non-technical public in such a way that prejudiced conclusions will not be reached and an unfavorable reaction created against the engineering profession.

Several years ago numerous miscellaneous agencies and the newspapers set forth the advantages of mine-mouth power plants. The idea was so presented that the public grasped the idea that it was the only solution to the location of power plants. To see a great station erected in or near a city and at some distance from coal mines, was immediately passed judgment upon by the public as a colossal engineering blunder. The question of water supply meant nothing to the public because that phase of the problem had not been presented to them.

From bond salesmen on down to janitors we can now hear of the wonders to be derived from superpower. When asked to explain what their understanding of superpower is, we find invariably that it involves the construction of stations of super-size and super-economy. It is a popular and a convenient term but one which is grossly misunderstood. Long before the public wakes up to a true understanding, much unfavorable comment will have been passed regarding the work being done by many groups of engineers.

Engineers can do a great deal toward remedying this condition by taking a more active interest in public affairs and in that engineering publicity which reaches the general public. Further, those agencies which are closely allied through business affiliations with the engineering profession will do well to consult engineering specialists in order that they may broadcast whole truths rather than half truths. Finally, where these agencies find it expedient to appoint a committee which must deal with problems of a technical agency, let that agency use enough foresight to have on that committee engineers who are conversant with the problems under consideration.

Startling Developments in Pulverized Coal Practice

Experience is sometimes one of the greatest obstacles in the path of progress. This is by no means the general rule but in certain exceptional cases, the greatest advances in a particular field are made by men not hampered by a knowledge of past achievements in that field. A novice will attempt things the expert regards absurd, yet once in a while the "foolish" idea of the novice when put into practice produces amazing results.

Ever since the invention of the steam engine we have been burning coal under boilers. From crude hand fired grates of the early days we have passed through all the stages of development to modern automatic stokers and the pulverized fuel furnaces of today. It is a far cry from the hand-fired boilers of the last century to the cathedral-like air and water cooled pulverized coal furnaces of the modern generating station.

But the burning of pulverized fuel is in itself a new development and its commercial application dates back to about 1916—less than ten years back. Now ten years is relatively a short interval of time and despite the wonderful development to which pulverized fuel burning has been carried in that short time it is hardly to be expected that perfection has been attained.

One of the most important factors in the design of a pulverized coal installation is that of furnace volume, and in many cases, especially where it is desired to adapt pulverized coal to existing stoker-fired installations this is a serious obstacle. Yet in the past the principles involved in the process of burning coal in the powdered form seemed to demand extremely large furnace volumes, and no way could be found to avoid the difficulties introduced by this requirement. Apparently, large furnace volume was an inherent necessity and could not be avoided. For every 25,000 or 30,000 B.t.u. liberated, at least one cubic foot of combustion space was necessary.

Improvements were made in furnace construction, refinements were made in the matter of supplying air and fuel and in removing products of combustion but still no radical increases in combustion rates were forthcoming.

But now from a clear sky comes the announcement of pulverized coal furnaces with combustion rates of *three quarters of a million* B.t.u. per cu. ft. of furnace volume; 30 times that attained by the best commercial practice of today! This performance is so amazing that it makes the most experienced investigators in the field sit back and rub their eyes in astonishment. How is it done?

With this new "well" type furnace, a number of fuel nozzles or burners are arranged tangentially around a cylindrical furnace. The resultant action of these burners is to produce what is virtually a tornado of hot gases, directed vertically upwards through the boiler tubes. The velocity of this blast may be regulated by means of the air supplied to the furnace.

According to the reports of the investigators the gases are the most completely burned out they have ever seen and the flame length is extremely short. With this system, a furnace for a 1500 hp. boiler operating at 500 per cent rating is an 8 ft. cube!

Now how did this development come about? We do not know but it was certainly *not* attained by following conventional practice. Heretofore we have built all our pulverized coal furnaces much along the order of hand and stoker fired furnaces. No one, it seemed, recognized the fact that here was a new principle of combustion and that its successful solution demanded an entirely new method of attack. The results obtained were encouraging but at best they were about on a par with the older method of burning coal.

But in this new development the investigators have disregarded all former furnace designs and have broken away entirely from conventional practice. The results are so revolutionary that it makes us wonder what might be done with other equipment by breaking away from conventional practice. Our thoughts run in channels and unless we sometimes deliberately find our way out of these channels we cannot expect to discover any new stretches of territory. The process of emancipating ourselves from the prejudices formed by past experience may be painful but it proves not only valuable but extremely refreshing at times.

Electrical Engineers Discuss Power Problems

SPRING CONVENTION OF AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS AT ST. LOUIS BRINGS FORTH LATEST DEVELOPMENTS IN THE ELECTRICAL ART

WITH ALMOST the entire first two days of the proceedings devoted to the discussion of power problems, the Spring Convention of the American Institute of Electrical Engineers held at the Hotel Chase, St. Louis, Mo., April 13-17, was of particular interest to power plant men, although there was no lack of technical material on other phases of the electrical art.

An excellent program, both technical and social, had been arranged by an enthusiastic committee drawn from practically all electrical interests in St. Louis; throughout the entire weeks no efforts were spared in making it a complete success.

Technical activities began Monday afternoon with the opening of the Power Plants Session. This discussion at this session because of its intimate relation with the field covered by this publication will be probably of greater interest to the readers than that presented at any of the other sessions. The main topics of this session included descriptions of the mechanical and electrical features of four of the largest and representative power plants constructed in this country within the past two years. These were in the order of their presentation, Trenton Channel Station of the Detroit Edison Co., Philo Station of the Ohio Power Co., Weymouth Station of the Edison Electric Illuminating Co., of Boston, and Cahokia Station of the Union Electric Light and Power Co.

The paper on the Trenton Channel Station was presented by Prof. C. F. Hirshfeld of the Detroit Edison Co., and dealt with the data and engineering reasoning leading to the design of the plant. This station was fully described in Power Plant Engineering in the June 1, 1924, issue and no attempt will be made here to review the structural details. With regard to the use of pulverized coal for fuel at Trenton Channel, Mr. Hirshfeld stated, the decision to use this type of fuel was based upon four main factors.

First, the pulverized fuel method had been developed to such an extent that continuity of service approximately equal to that obtained with stoker firing could be obtained. Second, the total cost of steam would not be any higher with pulverized fuel than with stokers. Third, it appeared possible to obtain a flatter efficiency curve over a wide range with pulverized fuel than with stokers, and, fourth, it seemed that a pulverized fuel plant would be less dependent on the supply of a particular quality of coal. In fact, the final decision in favor of pulverized fuel was based largely upon the fourth conclusion, namely, greater flexibility with respect to character of coal.

Another point of interest regarding the Trenton Channel plant was the reason for installing a Cottrel precipitator for removing dust from flue gases. It was due, said Prof. Hirshfeld, to the fact that the plant happens to be located within a short distance of a fine residential community and it seemed justifiable to spend some money in reducing the dust nuisance as much as possible. At present from 60 to 70 per cent of the dust is being removed in this manner.

The so-called loose connection, that is the lines of low capacity used between stations on the Detroit Edison System was criticised by several of the members as was also the fact that 132-000 v. equipment is installed at Trenton Channel while the operating voltage is only 120,000 v. This according to Mr. Summerhays was needless expense and such a high factor of safety was unnecessary.

Mr. Summerhays also believed that a tighter linkage between the Detroit Edison stations would be found advantageous, and in replying to this criticism Mr. Hirshfeld later stated that it was possible that at some future date heavier tie lies would be installed although up to the present, the loose linkage had always served their purpose admirably.

PHILO PRODUCES A KILOWATT HOUR FOR 14,500 B.T.U.

The second paper, namely that on the Philo plant was presented by E. H. McFarland, of the Beech Bottom Power Co. This plant is located about 10 mi. south of Zanesville, O., and is one station of a 132,000-v. system which is some 700 mi. from end to end, and which has a combined connected capacity of 223,000 kw. The boilers are operated at 650 lb. pressure, 700 deg. total steam temperature. A unique feature of this plant is that for the greater part of the year no circulating pumps are required, the condensing water having sufficient head to pass through the condensers without the use of pumps. At other times when the river is low, circulating pumps are operated.

All feed water at the Philo plant is treated by the lime soda process and then deaerated. This results in water of exceptional purity and it is only necessary to blow the boilers down about once every two weeks. The make up amounts to about three per cent. The plant has now been in operation for approximately six months, and during that time 90 million kw.-hr. have been produced. The generators have been operated 85 per cent of that time. According to Mr. McFarland, a water rate of 8 lb. of coal per kilowatt-hour has been obtained.

Reheating steam has been found a desirable feature at Philo anywhere from one-fourth to full load. All service from the plant is at 132,000 v. For the week ending April 4, with a 90 per cent load factor, based on 33,600 kw.-hr.

output net, a figure of 14,500 B.t.u. per kw.-hr. was obtained. Power used for operation of auxiliaries was 4.15 per cent of generated value. In summing up the performance of the station, Mr. McFarland stated that less difficulty had been encountered in the operation of this high pressure plant than with other stations of lower pressure.

Reasons for Selection of Stoker at Weymouth

I. E. Moultrop, of the Edison Electric Illuminating Co. of Boston, who presented the discussion on Weymouth station, did not agree with the other speakers in the superiority of pulverized coal and stated that at Weymouth, after extensive study, stokers were found to be the most economical. One reason for the selection of stokers was the fact that in Boston, the most economical fuel is the best fuel obtainable and also the most expensive. This coal is readily burned on stokers. The conditions at Boston, stated Mr. Moultrop, are different from those of the other stations mentioned at the session, they have no industrial load, no big customers and are thankful to get a 40 per cent load factor.

The performance at Cahokia station was briefly discussed by H. W. Eales, of the Union Electric Light and Power Co. This station he stated has fulfilled all of their expectations and at no time has the pulverized fuel system been the cause of interruptions. Starting with 19,310 B.t.u. per kilowatt-hour in Jan., 1924, they had brought their heat consumption down to 17,093 B.t.u. in Dec., 1924.

Other stations touched upon at this session by members of the respective companies were the Richmond Station of the Philadelphia Electric Co., Hudson Ave. Station of the Brooklyn Edison Co., and the Miami Fort Station of the Columbia Power Co.

Startling Developments in Pulverized Coal Furnace Design

Perhaps the most startling things brought out at this session were the predictions made by a representative of the Fuller Lehigh Co. in regard to the future possibilities of burning pulverized fuel. He referred briefly to the recent experiments that had been made with the so-called well-type of furnace wherein, instead of running about 25,000 B.t.u. per cu. ft. of combustion space as is usual with ordinary pulverized fuel furnaces, they had obtained ratings of 750,000 B.t.u. per cu. ft. of combustion space. This is simply amazing when it is considered in relation to what has been possible in the past. A furnace of this type for a 1500 hp. boiler, operated at 445 *per cent rating* is an *eight foot cube*. The speaker showed slides of such a furnace in operation.

The principle involved in this new development is a cyclone action induced by a number of burners arranged tangentially around a cylindrical furnace. The whirling action of the gases produces what is virtually a tornado of gases which sweeps upward with such a velocity, that a scouring off of the dead gases immediately next to the boiler tubes takes place. This increases the heat transmission and therefore the efficiency of the boiler. This layer of dead gases is said to be within 1/40 of an in. of the boiler tubes and in the ordinary furnace the travel of the gases of combustion is not fast enough to remove them. Experiments with this type of furnace have not gone far enough to state definitely what may result from the application of this principle, but preliminary experiments have so far justified all expectations.

A furnace of this type has been installed in the Sherman Creek station of the United Electric Light and Power Co., and while it has been in operation for some time, no definite data was available for presentation at the meeting, although the speaker stated that the performance obtained was entirely in accord with what had been anticipated and the efficiencies were from 3 to 5 per cent in excess of those obtained with ordinary pulverized fuel burning equipment.

Power Systems Session on Tuesday

On Tuesday morning at the Power Systems Session, four interesting papers were presented. These were, in the order of their presentation, as follows: 1. Interconnection of Systems with Frequency Changers, by H. R. Woodrow. 2. Eight years experience with Protective Reactors, by Lyman, Perry and Rossman. 3. Mississippi River Crossing of Crystal City Transmission Line by Eales and Ettlinger, and 4. Applications of Automatic Control to Substation Apparatus, by W. H. Millan.

Of this group that paper which perhaps invoked most discussion was that of Messrs Lyman, Perry and Rossman, all of Sargent and Lundy. This paper was particularly interesting because it presented detailed descriptions of 16 short circuits on different systems and the results of these failures as influenced by the use of reactors. In each case the reactors effectually kept the power concentration within such limits that the damage was localized. The conclusions reached by the authors were that short circuits in the largest power stations can be so controlled by the use of reactors that their destructive effects will be confined to the immediate vicinity of the arc.

In adding some remarks to this paper, Mr. Lyman presented interesting figures on the Windsor Power Station of the American Gas and Electric Corp. This was one of a number of stations, stated Mr. Lyman, which because of their nature were operated at extremely high load factors. During the past year Windsor has had a daily load factor of 93 per cent, a weekly load factor of 87 per cent and a yearly load factor of 60 per cent. Exactly one billion kilowatt hours were generated last year.

Crawford Ave. Station of the Commonwealth Edison Co., stated Mr. Lyman, would also be operated at an extremely high load factor.

The paper by Mr. Millan on the Application of Automatic Control to Substation Apparatus, was highly praised by several of the members as being an excellent example of constructive criticism of modern automatic equipment, which although highly developed is still far from being perfect.

Machinery Session Tuesday Afternoon

The first paper presented at the Machinery Session was that on Initial and Sustained Short Circuits in Synchronous Machines, by Prof. Karapetoff. This was a general treatment of the subject and the paper was delivered with the professor's usual wit and cleverness. Professor Karapetoff's paper was followed by a companion paper, Short Circuit Currents of Synchronous Machines, by R. F. Franklin of the General Electric Co. This showed the application to a number of practical cases of the general formulas for short circuit current as given in the preceding paper.

The paper, A Two Speed Salient Pole Synchronous Motor, by R. W. Wieseman, of the General Electric Co., was a remarkable example of the correct application of

theory to practice. The synchronous motor has been handicapped in the past because it is inherently a single speed machine. The special pole described in Mr. Wieseman's paper permits two speed operation of a synchronous motor to be obtained at high efficiency. The theory was worked out, and a 5000/2500 hp., 600/300 r.p.m., two speed motor was built without having first constructed a model of any kind. This motor proved to be entirely satisfactory and its characteristics obtained by test agreed closely with calculated characteristics.

The sessions on Wednesday and Thursday mornings were devoted to the subject of Communication and Marine Applications respectively. The former session was particularly well attended because of an interesting demonstration of a new type of loud speaker, by E. W. Kellogg and C. W. Rice of the General Electric Co. This loud speaker gives an output approximately proportional to the actuating force and is independent of the frequency. It was remarkably free from distortion and as Mr. Kellogg facetiously remarked, "spoke for itself."

Mining problems were taken up Friday morning and at the Industrial Session in the afternoon general power applications were discussed.

Among the inspection trips scheduled, the one that probably was of greatest interest and best attended was the trip to Cahokia on Wednesday afternoon. There the members were shown the practical application on a large scale of powdered fuel to steam generation. The second section of this station is just being completed and four turbo generators are installed. The 132 kv. outdoor substation now under construction was of particular interest to the purely electrical men.

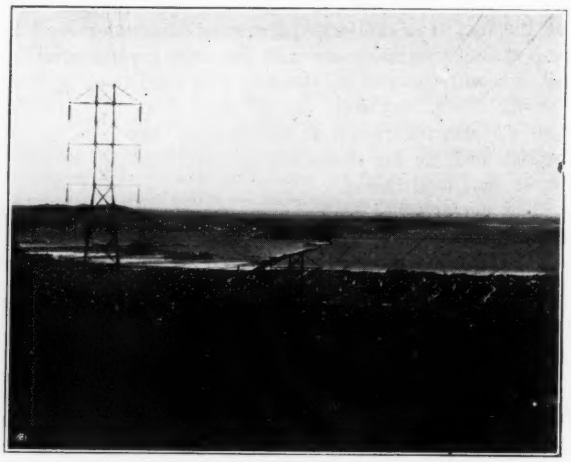
A smoker was held on Wednesday evening and on Thursday evening a dinner-dance was given in the Palm Room of the Hotel Chase. The latter was the gala social affair of the week and was thoroughly enjoyed by all who attended.

N. E. L. A. Will Inspect Western Hydro Projects

PUBLIC utility companies of the West have included many interesting inspection trips in their plans for entertaining approximately 5000 visitors to the forty-eighth annual convention of the National Electric Light Association which meets in San Francisco on June 15 to 19. Holding the annual convention on the Coast in 1925, has particular significance because of the extensive hydroelectric development programs which the utilities in California, Oregon, Washington, Idaho and Utah, have under way at the present time. During the present year 367,625 kv.a. of new hydroelectric capacity will be added to the lines of the electric service companies of the eleven Western states. Steam capacity will account for an additional 76,000 kv.a.

Present plans include a series of inspection trips to many of the large projects for the delegates to the convention. Those coming through the Pacific Southwest will visit the two new steam stations in Los Angeles, the 70,000-kw. Long Beach No. 2 plant of the Southern California Edison Co. and the 30,000-kw. Seal Beach plant of the Los Angeles Gas and Electric Corporation. A trip also is planned to the Big Creek-San Joaquin project of the Southern California Edison Co., where 1,300,000 hp. is in the course of development in a chain of eighteen hydroelectric plants.

The San Joaquin Light & Power Corporation will conduct a trip over its Crane Valley system of plants, including a visit to its Kings River project where work is under way on the Balch plant, containing the highest-head impulse turbines in North America. This station will operate under a head of 2470 ft. Trips will be made to the Pit River project of the Pacific Gas and Electric Co., where construction is progressing on two plants, Pit No. 3 and Pit No. 4, having an aggregate capacity of 200,000 kv.a. Pit No. 1 plant with an installed capacity of 70,000 kw.



SAN FRANCISCO GETS ITS POWER FROM THE SIERRA NEVADA MOUNTAINS OVER HIGH-VOLTAGE TRANSMISSION LINES

will also be visited. Delegates will also be given an opportunity of inspecting the Spaulding-Drum development of this utility.

Delegates making the trip through the Pacific Northwest will be taken over the Long Lake development of The Washington Water Power Co. at Spokane and over some of the Puget Sound Power & Light Co.'s more recent projects near Seattle. Arriving in Portland, they will be the guests of the Portland Electric Power Co. on a trip up the Columbia River Highway or an alternate trip to the Oak Grove plant of that company on the Clackamas River. This station contains the highest head-reaction turbines in the world, operating under a head of 860 ft. The convention program promises to be one of the most noteworthy in the history of the organization.

New Self Seat Valve Provides Uniform Contact Pressure

SEVERAL NEW lines of valves have recently been developed and placed upon the market by the Ohio Injector Co. of Wadsworth, Ohio. The Self-Seat Brass Valve and the Extra Heavy Iron Body Gate Valves here described are of particular interest.

A view of the self-seat brass valve is shown in Fig. 1. The principal feature of this valve is that the seat and disc are always brought into contact and held together by the same pressure, and it is so designed that this pressure can never be great enough to injure these parts. This action is altogether independent of the pressure applied

to the hand wheel and it is therefore impossible to destroy the seating qualities of the valve by rough and careless operation. It is an exceedingly practical valve for plants employing unskilled labor. The maker directs particular attention to its area which is not restricted by the extension of the stem into seat opening. Its great strength is due to the fact that there are only three openings in the body.

It can be mounted in any position and can be operated perfectly if the spring loses its temper or even if omitted altogether.

The Extra Heavy Iron Body Gate Valve, shown in Fig. 2, was designed for saturated steam working pressure

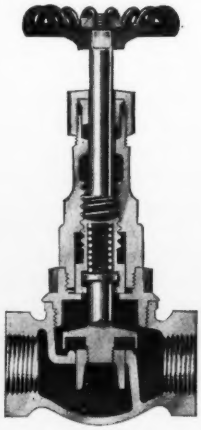


FIG. 1. THE O. I. C. SELF SEAT BRASS VALVE

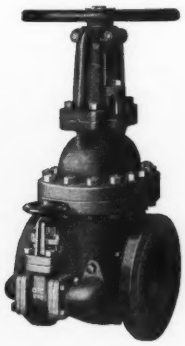


FIG. 2. O. I. C. EXTRA HEAVY IRON BODY GATE VALVE

up to 250 lb. and for a total temperature not over 500 deg. F.

In appearance this valve is attractive, being correct in design, embodying all the late features of iron valve construction, careful attention having been given in distributing metal to all points such as to afford unusually high factor of safety. Ample strength is afforded to withstand not only the working pressure, but also the mechanical changes caused by expansion, contraction and settling of pipe lines.

Body, bonnet and wedge are made of a high grade of semi-steel and the trimmings are of a special grade of bronze particularly adapted to this service. The body is fitted with heavy seat rings with long threads and wide seats, thus providing ample surface to withstand the heavy thrust from the wedge when seated.

The wedge is of heavy section and further strengthened by internal cast supports extending from one side to the other. It is faced on both sides with broad, heavy bronze rings which are provided with tangs which are expanded into corresponding grooves cut in the wedge. This construction effectively takes care of the expansion taking place between the ring and wedge under the widely varying temperatures found in high pressure service. In the outside screw type of wedge there is cast a heavy bronze sleeve in which is cut the long thread engaging with the stem. The wedge is provided with accurately milled slots which engage with cast ribs in the body. This has proven to be the most effective method of guiding the wedge to prevent chattering and undue contact between wedge and seat rings when the valve is being opened and closed.

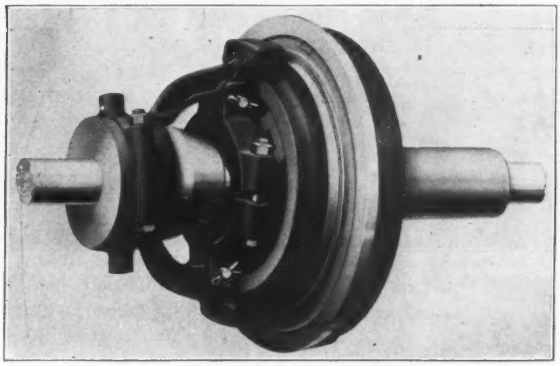
The stem is of heavy section and is provided with a strong thread of Acme form. It is made of bronze in the stationary stem type and of steel in the outside screw and yoke type. The stem thread contact is exceptionally long, thus insuring long life in this part. The gland is heavy and is bushed with bronze.

In the flanged type of valve the flanges are regularly finished with $\frac{1}{16}$ in. raised face. These valves are so constructed that when in wide open position they may be repacked under pressure.

Friction Clutch of Few Parts

FRICTION clutches are often conveniently applied to machines and countershafts. To meet requirements of this kind, there has been developed the Lemley model F clutch which is suitable for medium and light duty.

It has few parts, all of which are in plain view and readily accessible. Special tools are not required to adjust or completely to disassemble it. Uniform pressure on the friction surfaces is assured at all times and the two toggles are readily adjusted by means of one split ring nut. Free floating friction rings of fiber or asbestos brakelining material are used. This clutch is furnished for use as a



LEMLEY MODEL F CLUTCH IS SIMPLE AND RUGGED

sleeve clutch, cutoff coupling, or it can be bolted to the arms of pulleys, sprockets, gears or sheaves.

Other types of Lemley clutches are built for various classes of work and for heavy or light duty by W. A. Jones Foundry & Machine Co., Chicago, Ill.

New Industrial Crawling Tractor Crane

CRAWLING TRACTOR cranes have been developed to extend the usefulness of the locomotive crane beyond the limitation of rails and now several manufacturers of material-handling equipment have already entered this field, among them the Industrial Works, Bay City, Mich., who for the past 52 yr. have been building locomotive cranes and crane equipment.

They have just recently announced a new and greatly improved 10-T. crawling tractor crane. This crawler crane, known as their Type D.C., is similar in outward appearance to the former types of tractor cranes built by that company but its design embodies new engineering features such as split gears for propelling, increased speeds, double clutch mechanism, long tractor belts and independent functions.

The most important of all the new features is the system of split gears by which each tractor belt is separately controlled. Two concentric vertical propelling shafts at the axis of revolution lead two independent but concentric trains of spur and bevel gears, each operating one tractor belt. Each belt is directly controlled by two powerful friction clutches and brakes in the revolving upperworks, which gives independent, definite and easy control over each belt while propelling. This is an all gear drive from engine to sprockets with no chains in the mechanism.

All speeds of the motor operated crane have been increased 25 per cent which provides ample speed for the fastest possible handling of all materials. The double clutch mechanism by which the two slewing band clutches are operated by one lever makes for simple slewing. The direction of slewing is changed at will by the movement of the slewing double clutch lever. No reversal of the engine is necessary.

TRACTOR BELTS GIVE PLENTY OF STABILITY WHEN LIFTING OVER EITHER END

The crawling tractor belts are of ample length to give plenty of stability when lifting over either end, on any kind of ground. The center distance between the two end sprockets is 10 ft. All functions of this crane are independent of each other, which means certainty of operation. Separate levers actuating each function are conveniently placed on the operator's platform in the revolving upperworks. Different combinations of these independent functions may be utilized at one time to great advantage.

This crane can be equipped to operate with a steam engine, electric motor, gasoline motor or fuel oil engine of the Diesel type to suit operating conditions. It will operate with clamshell or dragline bucket, electro-magnet, hook and block or grapple. It is readily convertible into a shovel or a pile driver. Any equipment that operates on a boom can be applied.

AS A MATERIAL for reinforcement in concrete, rail steel has received the approval of the American Society for Testing Materials and a specification, A-16-14, has been approved. This steel is used railroad rails which have been reheated and rolled into bars. It was originally of high grade, high carbon steel and has already been tested in severe track service.

It is not to be confused with "rerolled" material, although the term rerolled is used in connection with material made from rail steel bars, usually scrap which did not pass inspection for rails.

Program of A. S. M. E. Spring Meeting

AT THE Spring Meeting of the American Society of Mechanical Engineers, which will be held this year in Milwaukee, on May 18 to 21, are many papers of interest to power plant engineers. In addition to the technical sessions, arrangements have been made for excursions to points of interest to mechanical engineers for each of the four afternoons of the meeting. Inspection trips will be made to the Milwaukee Activated-Sludge Sewage-Disposal Plant, the Phoenix Hosiery Co., the Palmolive Co., Allis-Chalmers Co., Eline's Inc., Robt. A. Johnston Co., Kearney and Trecker Corp., Vilter Manufacturing Co., Riverside Pumping Station, Falk Corp., Lakeside Power Station and the Nordberg Manufacturing Co.

Three new A.S.M.E. power test codes will be discussed in public hearings, one of these codes being for testing refrigerating systems at which the American Society of Refrigerating Engineers will be asked to join. The other codes to be discussed are the testing of centrifugal and rotary pumps and reciprocating steam driven displacement pumps. It is planned to hold the technical sessions during the mornings of Tuesday, Wednesday and Thursday, all meetings being held in the Hotel Pfister. Papers of particular interest to power plant engineers are as follows: Tuesday morning: The Parallel Operation of Hydro and Steam Plants, by F. A. Allner; Mechanical Features Affecting the Reliability and Economical Operation of Hydro-Electric Plants, by E. A. Dow and Mechanical Problems of Hydraulic-Turbine Design, by W. M. White. Tuesday evening will be devoted to engineering problems of local interest, the papers being: The Activated-Sludge Sewage-Disposal Plant of Milwaukee, by John A. Wilson; Critical Study of Heat and Power Requirements of Sewage-Disposal Plants, by Robert Cramer; Duty Tests of Vertical Triple-Expansion Pumping Engines, Milwaukee, Wisconsin, by Chas. A. Cahill and the Economical Advantage of Cities Having Diversified Industries, the author of which has not been announced. On Wednesday morning an Industrial Power Session will be held at which the papers to be presented are: Torsional Vibrations and Critical Speeds of Shafts, by A. Lack and Tests of a Uniflow Engine, by G. H. Barrus. On Thursday morning a Steam Power Session will be held at which the following papers will be presented: Analysis of Power Plant Performance Based on the Second Law of Thermodynamics, by W. L. DeBaufre; A Review of Steam Turbine Development, by Hans Dahlstrand; Rational Design of Covering for Piping Carrying Steam up to 800 deg. F., by W. A. Carter and E. T. Cope; Lake Water for Condensers, by A. G. Christie and Comparison of Actual Performance and Theoretical Possibilities of the Lakeside Station, by M. K. Drewry.

CONGRESS HAS MADE an appropriation of $315,000 for a continuation of the survey of the Tennessee River and its tributaries, which contemplates converting the Tennessee and parts of its tributaries into navigable streams and making it possible to utilize the water power available. It has been shown that 3,000,000 hp. can be secured by developing these streams. The project contemplates the construction of ten dams.

Midwest Power Show and Mechanical Exposition

WHAT PROMISES to be one of the most important events of the year in the power plant field is the exposition of power and mechanical equipment which will be held in the Municipal Auditorium, Milwaukee, Wis., May 18 to 21. The dates chosen are simultaneous with the spring meetings of the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers and the annual state convention of the National Association of Stationary Engineers, which will be held in the same city.

Over 300 booths have been leased, all of which will be occupied by the leading manufacturers of mechanical and electrical equipment used in power, refrigeration and industrial plants. All the latest designs and models of equipment will be on exhibit and many of the manufacturers are planning to show their products in actual operation. This is the first exhibition of its kind to be held in the Middle West and it is hoped that engineers of that section of the country will take advantage of the opportunity to study first hand all the latest developments in the field.

News Notes

THE STANDARD TURBINE CORPORATION has recently appointed Edward P. Johnson, David-Whitney Building, Detroit, Mich., as its district representative.

W. H. NICHOLSON AND CO. has recently placed in the hands of Kilner-Mills Co., General Motors Building, Detroit, the agency for the entire state of Michigan for its steam specialties.

ANNOUNCEMENT comes from Hugh E. Weightman, St. Louis, Mo., that he has resigned as chief of the consulting department of the Maphite Co. of America and has returned to the practice of consultant on fuel engineering problems.

CHAS. CORY & SON, INC. has opened an office at 22 West Quincy St., Chicago, in charge of Harry D'Almaine, who will be district manager. This office will handle sales of the company's equipment for both stationary and marine power plants.

ANNOUNCEMENT HAS JUST been made of the consolidation of the Pittsburgh Piping and Equipment Co. and the American Foundry and Construction Co., the object of the consolidation being to strengthen their position as fabricators of power piping in the country. The officers of the former company will be connected with the new organization and the combined business will be operated by the Pittsburgh Piping and Equipment Co., which will occupy its new plant located in Pittsburgh, where the fabrication of all materials will be carried on. The officers of the company will be as follows: George H. Danner, president and general manager; Morgan B. Schiller, vice president; Charles R. Rall, vice president and treasurer; W. R. Neely, secretary; Robt. Whyte, general manager of sales; Louis K. Hamilton, assistant secretary and Karl Tiegel, manager of purchases.

HOMESTEAD VALVE MFG. CO. has recently appointed the McArdle and Walsh Co., of Baltimore, Md., as agent for its products in cities of Baltimore, Washington and surrounding territory.

G. D. HETTRICK, formerly assistant chief engineer at the East Bridgewater plant of the Edison Electric Illuminating Co. of Brockton, Mass., has been appointed plant superintendent of the new Somerset station of Montaup Electric Co., Somerset, Mass.

THE DEFENDER AUTOMATIC REGULATOR CO. will move to its new offices at 308-310 So. Eighth St., St. Louis, on May 1. In the new quarters, which is a building of two stories, the company will have over three times its present shop and office space.

DAYTON-DOWD CO. has recently opened an office in Detroit, in the David-Whitney Building, which will be in charge of E. E. Maher and E. P. Johnson, and appointed the Power Equipment Co., 131 State St., Boston, as sales representative for the New England District.

LEONARD C. RENNIE, who for a number of years has been connected with the advertising department of the Westinghouse Electric and Manufacturing Co. at East Pittsburgh, has recently assumed responsibility for the general publicity work of the Foxboro Co., Inc., Foxboro, Mass.

THE MARION MACHINE, FOUNDRY AND SUPPLY CO., of Marion, Ind., recently announced the purchase from the Swartwout Co., of Cleveland, Ohio, all of the machinery, good will and patents covering Swartwout metal buildings. The manufacturing equipment will be shipped to Marion, Ind., where a new building is in process of erection.

DEAN HILL PUMP CO. has just announced that it has acquired the Hill Pump and Turbine Works, formerly a division of the Midwest Engine Corporation. The new owners have had 50 yr. experience in the manufacture of pumping machinery and the former organization of the company recently acquired will remain unchanged for the manufacture of Hill pumps and Wait turbines.

O. L. Hyatt, who for the past 20 yr. has been associated with the electrical development of Chicago's suburbs, died of heart disease, on March 30, at his home in Chicago Heights. Mr. Hyatt was born in 1870, in St. Louis, Mo., and became associated with the North Shore Electric Company in 1903. This company was one of the predecessors of the Public Service Co. of Illinois. From superintendent of the Maywood district he was transferred to the district managership of the Chicago Heights district, which position he retained when the Public Service Co. took over the North Shore Electric Co.'s properties. This position be held up to the time of his death.

IN THE CASE of Northern Equipment Co., manufacturers of the Copes feed-water regulator, vs. McDonough Automatic Regulator Co., the Sixth Circuit Court of Appeals sitting at Cincinnati has upheld the validity of the Copes patent, No. 1,148,483 dated July 27, 1915, which covers feeding water continuously to boilers while under load, automatically lowering the water level when load is heavy and raising the level when load is light. It is a method patent, covering any device which feeds a boiler continuously and varies water level inversely with load.

THE S. OBERMAYER CO. has just let contracts for installing equipment at its Cincinnati, Ohio, plant, to extend its activities in the manufacture of its refractories. This new manufacturing unit will cost approximately $25,000, and the company hopes to be on production within the next few months.

SECURITY ICE AND COLD STORAGE Co., San Jose, Cal., is now completing the installation of a third unit by the addition of a 12½ by 24-in. duplex ammonia compressor made by the Vilter Mfg. Co. This unit is direct connected to a General Electric Co. synchronous motor and will increase the capacity of the refrigerating plant to 320 T. The construction work has been under the supervision of K. G. Lister, chief engineer of the company.

Catalog Notes

THE POOLE ENGINEERING AND MACHINERY Co., of Baltimore, Md., has just issued a bulletin describing and illustrating the Poole method of making machine molded gears.

"SPEED AND POWER" is the title of a booklet recently issued by the Boston Gear Works Sales Co., Norfolk Downs, Mass., which describes the Boston reduction units and shows the series which this company manufactures.

THE BUFFALO FORGE Co., Buffalo, New York, has recently issued a folder, describing the Buffalo Breezo-Fin Heaters. These units are a combination of radiators and fans and are particularly adaptable to factory use.

PAIGE & JONES CHEMICAL Co., Inc., New York City, has recently issued a bulletin, describing the Paige-Jones upward flow zeolite water softeners. The bulletin describes the zeolite method of water softening and the upward flow principle employed in the equipment made by this company. It also contains several views of the equipment as installed in industrial plants.

REPUBLIC PYROMETERS are described in a catalog just issued by the Republic Flow Meters Co., of Chicago, Ill. This catalog points out the applications of pyrometers to various industries and describes the various types of indicating, portable and recording pyrometers manufactured by this company. The catalog also contains a great amount of technical information, charts and diagrams.

ELECTRIC MACHINERY MANUFACTURING Co., Minneapolis, Minn., has just issued its Bulletin No. 875, dealing with the application of motors in pulp and paper mills. The bulletin recites the advantages of synchronous motors for this service, giving characteristic curves and other technical data essential to the selection of motors for application to various paper mill equipment.

"THE HARRINGTON STOKER" is the title of a catalog just issued by the Riley Stoker Corporation, Worcester, Mass. This catalog gives the 10 principles of design incorporated in the Harrington stoker and shows how they have been worked out in practical application. It also contains a number of drawings showing the application under different types of boilers and several installation views are shown.

THE GOODYEAR TIRE AND RUBBER Co., INC., Akron, Ohio, has just issued its Handbook of Mechanical Rubber Goods covering all rubber products known as mechanical goods made by this company. Power transmission by belting, transmission belt, conveyor belt, elevator belts, cone belts, belt fasteners, belt making, hose, motor vehicle accessories, railroad goods, pump valves and printers' supplies are some of the principal topics dealt with in this interesting new handbook.

THE USES of Goetze Flexible Metallic Packing are described in a folder recently issued by the Goetze Gasket and Packing Co., 17 Allen Ave., New Brunswick, N. J.

CATALOG 85 has just been issued by the Hoppes Manufacturing Co., Springfield, Ohio, illustrating and describing the Hoppes feed-water heaters, V-notch meters, live steam feed-water purifiers, steam separators, oil eliminators and exhaust heads.

THE HOLOPHANE GLASS COMPANY, New York, N. Y., has issued a new edition of the Holophane Catalog. This publication, as its name implies, is a combination data book and catalog and includes several new developments which the Holophane Co. has brought out in the last year.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for April 1, 1925.

State of Illinois,
County of Cook,
ss.

Before me, a Notary in and for the state and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:
Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock).
Technical Publishing Company, Chicago, Ill.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state).
There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is ..... (This information is required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 28th day of March, 1925.

Herman A. Dick.

(My commission expires Feb. 2, 1925.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the postoffice. The publisher must publish a copy of this statement in the second issue printed next after its filing.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Worlds Without End

Change is the law of man and his environment. All Nature conspires against fixation of form. Turn where he will for his life work, man confronts the ceaseless mutation of matter.

In the face of these conditions, in fact, because of them, men have arisen who have made their marks in all ages and mankind has built its successive civilizations.

Search for the secret of success, individual or collective, in the present day or back to the most remote times and it is not found in preservation of forms and conditions alone but in the control of the changes which must sooner or later take place.

While nothing may be eternally preserved and nothing completely destroyed, vast strides have been made in prolonging the life of chosen forms and in destroying the forms which have outgrown their usefulness to rebuild better ones.

Through science, education and application, man comes more and more into control of this process of changing forms. In our physical existence, we have added years to the average of life and made each year more useful in greater freedom from disease and discomfort.

This great progress in the preservation of life and physical powers has been made only through constantly increasing study, sacrifice, care and attention, not alone by the discoverers and leaders in medical, dietary and sanitary science but by teachers, law-makers and law enforcers, by organizations of all kinds, and finally by every individual throughout the land.

Cut off the millions of dollars spent for education and enforcement of health standards, relax the vigilance in community or home, let the people forget what is constantly being taught, even for a year, and uncounted lives would pay the price.

Not less startling would be the price we would pay for such relaxation in any other field of human endeavor.

Whether you have grown a few flowers, a home garden, or the harvest of a thousand acres, you have had first-hand knowledge of the requirements of fertilization, cultivation, combating plant pests and diseases.

No sooner does a shaft begin to rotate in the power plant than the invisible molecules in its structure have commenced a more rapid deterioration. Science can foretell the year when that shaft should be removed from service.

In the years in between, however, the care and attention of its operators and the provisions made by its owners are the determining factors in its life.

It may be ruined in a day or preserved to its full life of usefulness by so small a matter as proper lubrication or lack of it.

In like manner there are a thousand and one places in the power plant as in every other field and business and in every life, where eternal vigilance and constant expenditure of time and money is the price of freedom from loss and disaster.

While it is evident that treasure must be poured out for care and repair of every structure that is to fulfill its normal period of usefulness, from our bodies to our businesses, it is likewise evident that mere preservation in itself is deterioration.

So interrelated are all human activities, so interwoven all the factors in human destinies, that, literally, the whole world must stand still, if a single man or thing in it is to stand still and maintain its relative position.

Even in so personal a matter as physical health, a man may not grow old according to the ways he was taught in his youth. He will wake up some morning and find himself competing with hard-playing, hard-working men of his own age who have developed an entirely new set of health rules.

Each year's harvest must compete with the better plantings, cultivation and harvest of that year, not those of the previous year.

In the power plant field each day, machines, men and methods are placed in competition with the best of all the yesterdays.

Nowhere in the whole world are the ways of a generation, a year or a day ago sufficient for success today, this year or in this generation.

Men build for today and tomorrow. They look to the past only for the trends and rates of progress; never for its limitation nor its standards. To what they spend for care and repair they add the extra that is necessary to keep apace with ever-increasing advancement.

Men with the spirit of modern life, a distinctively American spirit, are not content to keep pace with progress.

Men with this spirit want their children to have a better chance in a better life than they had themselves. To such men, next year's crop must be nearer the best of all of next year's crops; the new plant must be a better plant than any other plant.

To attain, even for a time, the championship in a field, men give the final flower of effort.

These are the pace-makers, the conquerors, the men of all men, who, alone, liberate their own greatest powers and who are the great liberators of mankind.

Though any art is long and all life is fleeting, the art of living is in achieving. Eternal youth is in the men and the organizations of men who see their worlds without end.

To serve such men Power Plant Engineering is published. It cannot interest any other kind. It cannot exist without conforming to this law of ever-continuous betterment and growth.

From men to men, plants to plants, laboratories to machine shops, buyers to sellers it must carry more effectively the best of the field's achievements.

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